

[54] **ELECTROMAGNETIC COUPLING WITH PERMANENT MAGNETS**

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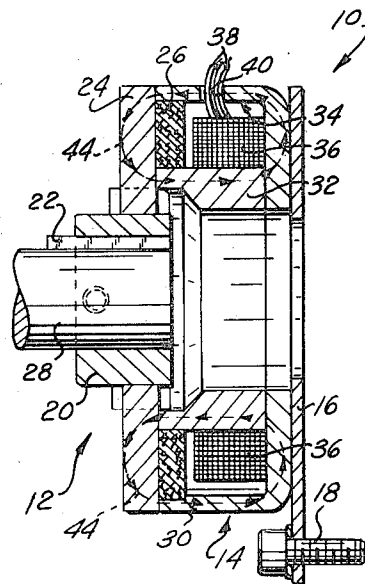
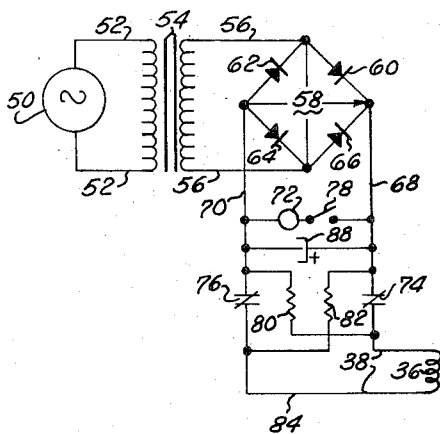
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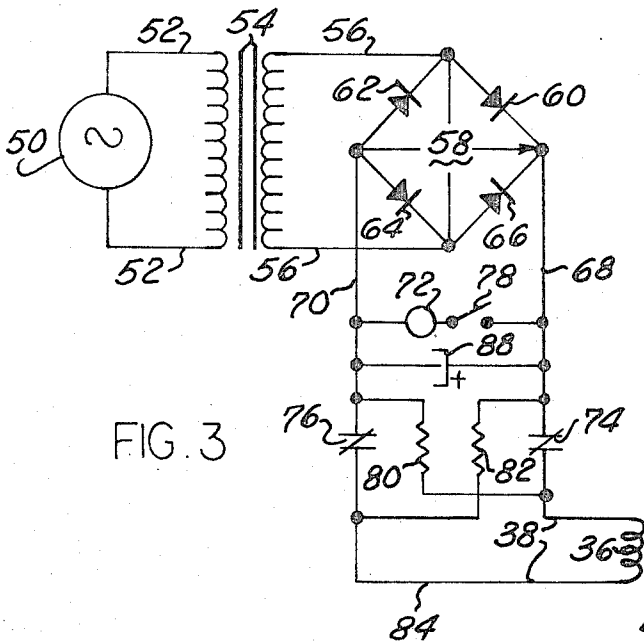
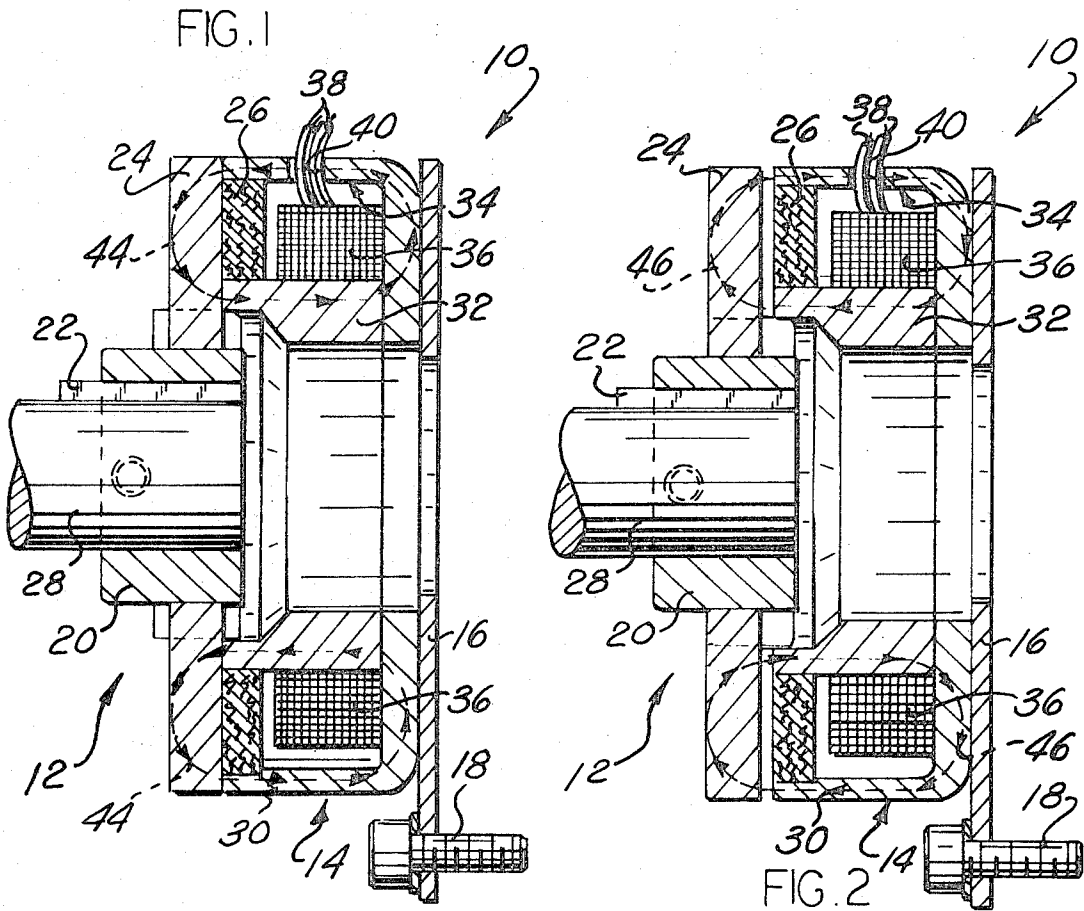
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[57] **ABSTRACT**

A magnetic coupling comprises an armature assembly having an armature plate formed of a material which is readily magnetizable to a first polarity and a second polarity opposite from the first polarity, a pole assembly, a coil energizable to magnetize the armature plate to its first polarity and to its second polarity, a power supply for energizing the coil and means for energizing the coil to a first polarity upon deenergization of the power supply. Energization of the coil to the first polarity effects magnetization of the armature plate to its first polarity to effect engagement of the armature plate and friction material disposed on the pole assembly. Energization of the coil to a second polarity is operable to effect demagnetization of the armature plate to its second polarity to effect disengagement of the armature plate and the friction material of the pole assembly. The means for energizing the coil to its first polarity upon deenergization of the power supply includes an energy storage means which provides a fail-safe mode of operation to insure that the armature plate engages with the friction material of the pole assembly upon deenergization of the coil by the power supply.

10 Claims, 3 Drawing Figures





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ELECTROMAGNETIC COUPLING WITH PERMANENT MAGNETS

The present invention relates to a new and improved magnetic coupling and more specifically to a magnetic coupling wherein one of the coupling members is formed of a material which is readily magnetized to different polarities to effect movement of the coupling members between an engaged and disengaged position.

Known magnetic couplings which incorporate permanent magnet materials generally are limited in that the permanent magnet material may be magnetized in a single direction for effecting engagement of the coupling members. Separate means are then provided to effect disengagement of the coupling members. One of these known devices is shown in the Stevenson U.S. Pat. No. 3,292,756 which disclosed the use of Alnico 5 or a soft ferrite as the permanent magnet material. Such material is magnetized to effect engagement of the coupling members. Springs are employed for effecting disengagement of the coupling member. Such known constructions of permanent magnetic couplings do not lend themselves to perform as fail-safe devices due to the broad dimensions of the hysteresis curve at the zero line. Moreover, as operating conditions vary, such as temperature, the high reluctance of the known magnetic devices make demagnetizing the magnetic material difficult so that separate means such as the springs disclosed in the Stevenson patent must be used to effect disengagement of the coupling members.

Accordingly, it is an object of the present invention to provide a new and improved magnetic coupling which overcomes the hereinabove discussed disadvantages and wherein one of the coupling members includes a material which is readily magnetizable to different polarities to effect movement of the coupling members to their engaged and disengaged positions.

Another object of the present invention is to provide a new and improved magnetic coupling including a driving and a driven member having an engaged position and a disengaged position, one of the driving and driven members including a readily magnetizable material, actuating means for moving one of the driving and driven members relative to the other of the driving and driven members to effect movement of the members between the engaged and disengaged positions, the actuating means having a first condition adapted to magnetize the one member to a first polarity to effect movement of the one member to one of the positions and a second condition adapted to magnetize the one member to a second polarity opposite the first polarity to effect movement of the one member to the other of the positions, and means for magnetizing the one member to the first polarity to insure that the one member is in the one position in response to deenergization of the actuating means.

A further object of the present invention is to provide a new and improved magnetic coupling as defined in the next preceding paragraph wherein the one member formed from a readily magnetizable material consists of a high carbon steel having a carbon content of between 0.4 and 1.2 percent.

Still another object of the present invention is to provide a new and improved magnetic coupling as defined in the next preceding paragraph wherein the actuating means includes a coil disposed on one of the driving

and driven members and the means for magnetizing the one member to the first polarity includes energy storage means connected across the coil for energizing the coil to polarize the magnetic material in the one member in a predetermined direction in response to deenergization of actuating means.

Another object of the present invention is to provide a new and improved magnetic coupling including a pole structure, an armature structure comprising a permanent magnetic material which is readily magnetizable to a first polarity and to a second polarity opposite the first polarity, the armature structure being movable relative to the pole structure between a first operating position in which the armature structure is engaged with the pole structure and a second operating position in which the armature structure is spaced from the pole structure, an electrically energizable coil secured to the pole structure for creating a magnetic field for magnetizing the armature structure, means for energizing the coil to a first polarity to establish a magnetic field adapted to magnetize the magnetic material of the armature structure to the first polarity and for energizing the coil to a second polarity to establish a magnetic field adapted to magnetize the magnetic material of the armature structure to the second polarity, the armature structure when magnetized to the first polarity effecting movement of the armature structure to the first operating position and when magnetized into the second polarity effecting movement of the armature structure to the second operating position, and means for energizing the coil to the first polarity in response to deenergization of the means for energizing the coil.

Another object of the present invention is to provide a new and improved magnetic coupling as defined in the next preceding paragraph wherein the armature structure is formed from high carbon steel having a carbon content of between 0.4 and 1.2 percent and wherein the means for energizing the coil to the first polarity in response to deenergization of the means for energizing the coil comprises energy storage means connected to the coil.

Further objects and advantages of the present invention will become apparent from the following detailed description thereof taken in conjunction with the following drawings wherein:

FIG. 1 illustrates a cross sectional view of a preferred embodiment of the present invention wherein the armature plate has been magnetized to a first polarity to effect engagement of the armature and pole assemblies;

FIG. 2 is a view similar to FIG. 1 wherein the armature plate has been magnetized to effect disengagement of the armature and pole assemblies; and

FIG. 3 is a schematic diagram of the circuitry for energizing the coil and the means for magnetizing the armature to the first polarity in response to deenergization of the power supply.

The present invention relates to a magnetic coupling including an armature assembly and a pole assembly. The armature assembly includes an armature plate formed from a readily magnetizable material. Attached to the pole assembly is an electromagnetic coil for effecting magnetization of the armature plate to a first polarity whereby the armature plate engages the pole assembly and adapted to magnetize the armature plate to a second polarity whereby the armature plate is dis-

engaged from the pole assembly. A power supply is provided for energizing the coil so that the armature plate may be polarized to either the first or the second polarity. Energy storage means is disposed between the power supply and the coil for energizing the coil so that the armature plate will be magnetized to the first polarity upon deenergization of the power supply to thereby provide a fail-safe electromagnetic coupling. Thus, in the event the power supply fails, the energy storage means will insure that the armature plate is engaged with the pole assembly.

The magnetic coupling, illustrated in FIG. 1, comprises in general a brake 10. The brake 10 includes an armature assembly 12 and a pole assembly 14. The pole assembly 14 includes a mounting plate 16 which is fixed by a bolt 18 to a suitable structure not illustrated to prevent rotation of the pole assembly 14. The armature assembly 12 includes a splined portion 20 which is keyed to a driven shaft 28 for rotation therewith by a key 22. Fixed to the splined portion 20 for rotation therewith is an armature plate 24. The armature plate 24 is adapted to move between a first position in which the armature plate 24 engages with a friction material 26 disposed on the pole assembly 14 as is illustrated in FIG. 1 and a second position in which the armature plate 24 is spaced from the friction material 26 of the pole assembly 14. When the armature plate 24 is spaced apart from the friction material 26 of the pole assembly 14, as is illustrated in FIG. 2, the shaft 28 will be free to rotate. However, when the armature plate 24 engages with the friction material 26, the armature plate 24 will be braked and rotation of the shaft 28 will be prevented.

The pole assembly 14 includes an outer pole member 30 which is fixed to the mounting plate 16 and an inner pole member 32 which is disposed coaxially of the outer pole member 30. The outer and inner pole members, 30 and 32, respectively, cooperate to form an annular chamber 34 in which is disposed a coil member 36. The coil member 36 is operable to be energized to effect movement of the armature plate 24 between its engaged and disengaged positions relative to the friction material 26.

The coil 36 is fixed to the inner pole member 32 and is operable to be energized by a pair of leads 38 which are disposed through an opening 40 in the outer pole member 30. Energization of the coil 36 to a first polarity will effect engagement of the armature plate 24 with the friction material 26 and energization of the coil 36 to a second polarity, opposite the first polarity, will effect disengagement of the armature plate 24 and the friction material 26.

The armature plate 24 is formed from a readily magnetizable material which is capable of being magnetized to a first polarity when the coil is magnetized to its first polarity and a second polarity opposite the first polarity when the coil 36 is energized to its second polarity. Preferably, the armature plate is constructed from a high carbon steel having a carbon content between 0.4 and 1.2 percent. However, the armature plate could be constructed from steel containing an alloy having a carbon content of between 0.4 and 1.2 percent and a chromium content of between 0.1 and 1 percent.

When the coil 36 is energized to its first polarity a flux path 44 will be established from the coil 36, through the inner pole member 32, through the armature plate 24, and through the outer pole member 30 back to the coil 36. The flux path 44, which is disclosed for illustrated purposes as moving in a counter-clockwise direction in FIG. 1, will magnetize the armature plate 24 to the first polarity to thereby effect engagement of the armature plate 24 with the friction surface 26 of the pole assembly 14 so as to stop rotation of the shaft 28 keyed to the armature assembly 12. When the coil 36 is energized to its second polarity a flux path 46 will be formed from the coil 36 through the outer pole member 30, through the armature plate 24, and through the inner pole member 32 to the coil 36. The flux path 46, is illustrated in FIG. 2 as occurring in a clockwise direction due to the energization of the coil 36 to its second polarity. Energization of the coil 36 to its second polarity will be adapted to effect magnetization of the armature plate 24 to a second polarity, opposite the first polarity, so that the armature plate 24 will disengage from the friction material 26 to enable the shaft 28 to rotate freely. The coil 36 will be energized to control the polarity of the armature plate 24 and will not charge the polarity of the pole assembly 14. Hence, when the armature plate 14 is magnetized to its first polarity, it will have a polarity opposite to that of the pole assembly 14 and will be attracted thereto and when the armature plate 14 is magnetized to its second polarity it will have the same polarity as the pole assembly 14 and will be repulsed therefrom.

The construction of the armature plate 24 from a high carbon steel or a carbon and chrome alloy steel enables the armature plate 24 to be readily magnetized to a first polarity and a second polarity opposite the first polarity by energization of the coil 36. The use of high carbon steel significantly reduces the cost of the armature plate 24 over known constructions which utilize Alnico 5 or hard ferritic materials. Moreover, the utilization of high carbon steel enables the armature plate 24 to be readily magnetized between its first and second polarities so that the brake 10 may be readily energized and deenergized without hangups due to excessive contact arcing, temperature, or line voltage variations.

The coil 36 of the brake 10 is energized to its first and second polarities by a fail-safe circuitry illustrated in FIG. 3. The circuitry includes a source of power 50 which is connected by a pair of leads 52 to the primary coil of a transformer 54. The secondary coil of the transformer 54 is connected by a pair of leads 56 to a full wave rectifying bridge 58 which includes diodes 60, 62, 64 and 66.

The bridge 58 applies the rectified wave form along a pair of leads 68 and 70 with the lead 68 being positive with respect to the lead 70. Connected across the leads 68 and 70 is a relay 72 having a pair of normally closed contacts 74 and 76 series connected with the leads 68 and 38 and leads 70 and 38, respectively. A switch 78 is series connected with the relay 72 between the leads 68 and 70 and provides for energization and deenergization of the relay 72. When the switch 78 is in its open condition and the relay 72 is not energized a circuit will be completed through the lead 68, through the normally closed contact 74 of the relay 72, through the

lead 38 to coil 36 and through the normally closed contact 76 of the relay 72 to the lead 70 to effect energization of the coil 36 to its first polarity. Energization of the coil 36 to its first polarity will establish the flux path 44 which will magnetize the armature plate 24 to its first polarity to effectively brake the shaft 28. It should be appreciated that the coil 36 need only be energized momentarily to the first polarity to effect braking of the shaft 28.

A resistor 80 is connected from the line 70 to one of the leads 38 and a resistor 82 is connected from the line 68 to the other of the leads 38. The resistors 80 and 82 form a bypass circuit around the contacts 74 and 76 when the relay 72 is energized and the contacts 74 and 76 are opened. When power supply 50 is energized and the switch 78 is closed, the relay 72 will be energized to open the normally closed contacts 74 and 76. Opening of the contacts 74 and 76 will provide for current flow from the line 68 through resistor 82 to the lead 38 and through the coil 36. The current will then flow from the coil 36 through the resistor 80 to the line 70. When the contacts 74 and 76 are opened, the coil 36 will be energized to a second polarity which is opposite the first polarity to thereby establish the flux path 46 to magnetize the armature plate 24 to its second polarity to insure that the armature plate 24 does not engage with the frictional material 26. The switch 78 need only be closed momentarily to pulse the coil 36 to its second polarity. The energization of the coil 36 to its second polarity will insure that the armature plate 24 will move to its disengaged position due to the construction of the armature plate of carbon steel having a carbon content of between 0.4-1.2 percent. Moreover, due to the construction of the armature plate, the armature plate need only be demagnetized to insure that the armature plate 24 disengages from the pole assembly. While in some cases it might be desirable to magnetize the armature plate 24 to its second polarity, the armature plate 24 need only be demagnetized, due to the magnetic characteristics of the high carbon steel from which the armature plate 24 is constructed, to insure that the armature plate will move to its disengaged position.

An energy storage means in the form of a capacitor 88 is parallel connected to the relay 72 between the lines 68 and 70. When the coil 36 is energized the capacitor 88 will charge in a positive direction indicated by the plus sign in FIG. 3. The charging of the capacitor 88 in the positive direction will occur regardless of the condition of the relay 72 and the contacts 74 and 76 thereof. The capacitor 88 will not discharge when current is flowing through the bridge 58 to the coil 36 of the brake mechanism 10. However, when current ceases to flow to the coil 36 from the bridge 58, the capacitor 88 will discharge through the lines 68 and 38, through the coil 36, to the lines 38 and 70 to energize the coil 36 to its first polarity. A diode could be included in the line 68 or 70 between the capacitor 88 and the relay 72 to prevent the energization of the relay 72 by the discharge of the capacitor 88. Energization of the coil 36 to its first polarity will effect magnetization of the armature plate 24 to the first polarity to brake rotation of the shaft 28.

It should be appreciated that the capacitor 88 will provide for magnetization of the armature plate 24 to its first polarity to insure that the armature plate is in a

braking condition to brake the shaft 28 upon the loss of power to the coil 36. The discharging of the capacitor 88 to effect changing of the coil 36 to its first polarity will occur regardless of the condition of the switch 78, due to the fact that when power is lost from the rectifying bridge 58 when the switch 78 is closed, the relay 72 will be deenergized and the contacts 74 and 76 thereof will return to their normally closed condition. Thus, it should be apparent that the brake mechanism 10 will operate in a fail-safe mode and that whenever the coil 36 is deenergized the capacitor 88 will discharge to effect magnetization of the armature plate 24 to its first polarity to thereby effect engagement of the armature plate 24 and the friction surfaces 26 to brake the rotation of shaft 28.

The utilization of the capacitor 88 to effect operation of the brake 10 in a fail-safe mode is effective due to the fact that the armature plate 24 is formed of a high carbon steel. The construction of the armature plate 24 enables the armature plate to be readily magnetized to its first polarity by a short pulse from the capacitor 88 even if the armature plate 24 had been previously magnetized to its second polarity. It should be appreciated that if other material, such as Alnico 5 were substituted, the capacitor 88 would not be effective to effect magnetization of the armature plate from one polarity to a polarity opposite to that to which it was previously energized due to the magnetic characteristics of Alnico 5. Accordingly, a fail-safe brake mechanism of a reliable construction has been provided.

While the present structure of the magnetic coupling has been utilized in conjunction with a brake mechanism 10 the structure could also be incorporated in an electromagnetic clutch wherein the pole structure is free to rotate with another shaft attached thereto. In such a construction the capacitor 88 could be utilized to insure that the clutch is either in its engaged or disengaged position upon deenergization of the coil 36. Moreover, while the armature plate has been disclosed as being constructed of a magnetizable high carbon steel the pole structure could be constructed of a high carbon steel rather than the armature structure. However, manufacturing techniques favor the construction of the armature plate of the high carbon steel. It should be appreciated that while the power supply has been disclosed as a power supply which may continuously energize the coil to its first or second polarity, a pulsating power supply for effecting energization of the coil could be utilized by obvious modifications of the circuitry. The pulsating power supply would operate to pulse the coil in one direction to magnetize the armature plate to its first polarity and in another direction to demagnetize or to magnetize the armature plate to its second polarity.

From the foregoing, it should be apparent that a new and improved magnetic coupling has been provided which includes an armature structure capable of being magnetized to a first polarity and a second polarity opposite the first polarity and a pole structure having an actuating means therein for effecting magnetization of the armature structure to the first and second polarities. Moreover, energy storage means has been provided to insure that the armature structure will move to a predetermined position upon the loss of power to the actuation means.

What I claim is:

1. A magnetic coupling comprising rotatable driving and driven members, said driving and driven members having an engaged position establishing a driving relationship between said members and a disengaged position permitting relative rotation between said members, actuating means for axially effecting movement of said members between said engaged and disengaged positions, a power supply for energizing said actuating means to opposite polarities, one of said members being formed from a readily magnetizable material, switch means having first and second conditions for switching the polarity of said power supply to said actuating means, said actuating means adapted to magnetize said one member to a first polarity to effect movement of said one member to one of said positions in response to said switch means being in said first condition and adapted to magnetize said one member to a second polarity opposite said first polarity to effect movement of said one member to the other of said positions in response to said switch means being in said second condition, and means, parallel connected with said actuating means, for insuring that said one member is returned to said one position in response to deenergization of said power supply.

2. A magnetic coupling as defined in claim 1 wherein said readily magnetizable material comprises a high carbon steel having a carbon content between 0.4 and 1.2 percent.

3. A magnetic coupling as defined in claim 2 wherein said means for insuring that said one member is in said one position in response to deenergization of said power supply comprises energy storage means.

4. A magnetic coupling as defined in claim 1 wherein said actuating means includes a coil and said insuring means includes a capacitor connected across said coil for energizing said coil to a first polarity to magnetize said one member to said first polarity.

5. A magnetic coupling as defined in claim 4 wherein said driving member is an armature plate, said driven member is a pole member, said coil being mounted on said pole member, said one member being formed from a readily magnetizable material is said armature plate, said material comprising high carbon steel having a carbon content between 0.4 and 1.2 percent, said power supply energizing said coil to a first polarity to magnetize said armature plate to said first polarity and energizing said coil to a second polarity opposite said first polarity, to magnetize said armature plate to said second polarity, said capacitor acting to energize said coil to said first polarity in response to deenergization of said power supply to provide a fail-safe magnetic

coupling wherein said armature plate is in said one position when said power supply is deenergized.

6. A magnetic coupling comprising a pole structure having a friction surface thereon, an armature structure including an armature plate having a friction surface thereon, said armature structure connected to a shaft for rotational movement therewith, said armature plate comprising a material which is readily magnetizable to a first polarity and a second polarity, said armature structure adaptable to move axially from a first operating position in which said friction surface of said armature plate is engaged with said friction surface of said pole structure to a second operating position in which said friction surface of said armature structure is spaced from said friction surface of said pole structure, an electrically energizable coil secured to said pole structure for establishing a magnetic field, a power supply for said coil, means for switching said power supply to a first polarity to energize said coil to a first polarity to establish a magnetic field operable to magnetize said armature plate to said first polarity and switching said power supply to a second polarity to energize said coil to a second polarity to establish a magnetic field operable to magnetize said armature plate to said second polarity, said armature plate when magnetized to said first polarity effecting axial movement of said armature plate to said first operating position, said armature structure when magnetized in said second polarity effecting axial movement of said armature plate to said second operating position, and fail-safe means for energizing said coil to said first polarity to magnetize said armature plate to said first polarity in response to deenergization of said power supply, said fail-safe means acting to engage said friction surface of said armature plate to said friction surface of said pole structure to prevent relative rotation of said armature plate and said pole structure when said power supply is deenergized.

7. A magnetic coupling as defined in claim 6 wherein said armature plate is formed from steel having a carbon content between 0.4 and 1.2 percent.

8. A magnetic coupling as defined in claim 7 wherein said armature plate is formed from steel having a chromium content between 0.1 and 1.2 percent.

9. A magnetic coupling as defined in claim 8 wherein said means for energizing said coil to magnetize said armature plate to said first polarity in response to deenergization of said means for energizing said coil comprises energy storage means.

10. A magnetic coupling as defined in claim 9 wherein said energy storage means comprises a capacitor connected across said coil.

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