MAGNETIC COUPLINGS

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

Filed Feb. 19, 1958, Ser. No. 716,166
4 Claims. (Cl. 192—54)

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 actuable in one direction by permanent magnets located in a series magnetic circuit and is actuable 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 electromagnet coil has been deenergized.

Another object of the present invention is to provide a magnetic coupling which is actuable 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 disengagable 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 devise bypass, minor, secondary and/or auxiliary paths, and low impedance reluctance or interrupter rings for keeping 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 "full-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 coxial 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-
cent 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 flanged pole portion 26 and spaced radially from the cylindrical portion 25 of polepiece 22 a predetermined radial distance for a reason which will become apparent hereinafter.

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 magnet 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 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 legs 33 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 drivenly 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 12 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 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 aforesaid described 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 effectiveness of engaging 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, mirror, secondary and/or auxiliary fields for keeping the coupling engaged. Furthermore, the necessity for low impedance reactance 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 after application 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 Figs. 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 which in turn is splined to the rim 44 of 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 sleeve 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. The armature 40 is adapted for use with magnets 66 in a manner similar to that described for the magnets 27, having a con-
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 shield 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 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 release said armature.

2. A magnetic clutch as defined in claim 1 and wherein said series magnetic flux path is bevelled at an angle of 45 degrees with respect to said inner cylindrical portion to prevent short circuiting of said series magnetic flux path.

3. A magnetic clutch as defined in claim 1 and wherein said innermost end of said inwardly extending leg portion is flared 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 pole pieces having axially extending portions and inwardly extending leg portions, the axially extending portion of said first pole piece extending toward said armature and the axially extending portion of said second pole piece extending away from said armature, a plurality of permanent magnets disposed between said leg portions, a cylindrical sleeve concentric with said pole pieces and spaced inwardly therefrom, a stationary annular channel shaped member disposed between said sleeve and said axially extending portion of said second pole piece, 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 structure 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.

References Cited in the file of this patent

UNITED STATES PATENTS

2,275,839 Boehme --------------- Mar. 10, 1942
2,348,967 Duby ----------------- May 16, 1944
2,738,449 Mason --------------- Mar. 13, 1956
2,765,878 Pierce --------------- Oct. 9, 1956
2,823,776 Pierce --------------- Feb. 18, 1958
2,832,918 Pierce --------------- Apr. 29, 1958

FOREIGN PATENTS

D. 21,278 Germany --------------- Sept. 13, 1955