(12) UK Patent Application (19) GB (11) 2 141 496 A

(43) Application published 19 Dec 1984

(21) Application No 8410990

(22) Date of filing 30 Apr 1984

(30) Priority data
(31) 504665 (32) 15 Jun 1983 (33) US

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(51) INT CL[3]
F16D 65/21 55/00 H01F 7/06 // 7/18

(52) Domestic classification
F2E Q

(56) Documents cited
GB A 2020381 GB 0756202

(58) Field of search
F2E

(54) Electromagnetic caliper brakes

(57) Two electromagnetically actuated friction brakes (14, 14′) are disposed on opposite sides of a relatively thin armature disc (11) of low reluctance material. The poles (21, 26, 27) of one electromagnetic friction brake (14) are polarized oppositely from the aligned poles (21′, 26′, 27′) of the other brake (14′) to cause the flux created by each brake to thread axially across the armature disc (11) and interact with the flux created by the other brake so as to produce relatively high braking torque the two brakes are not only attracted to the disc but to each other.

Such polarisation may be achieved by connecting a dc voltage source to respective coils (22, 22′) of the brakes (14, 14′) in reverse fashions (see Fig. 4).

As shown, the poles are defined by respective studs received in holes in an oblong block (30) of friction material.

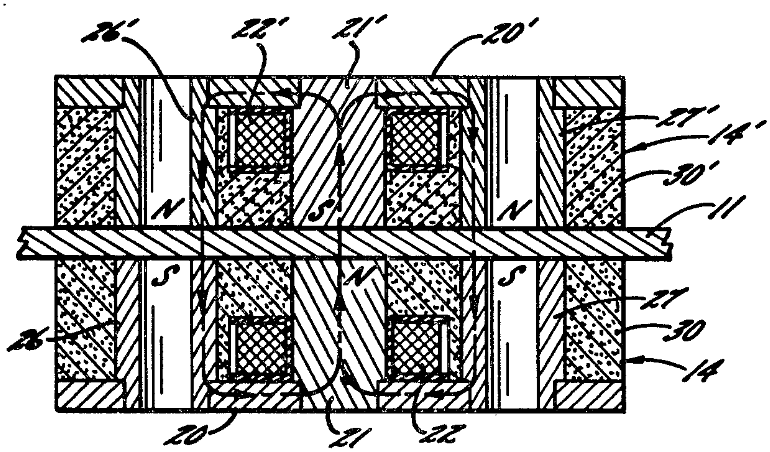

Fig. 3.

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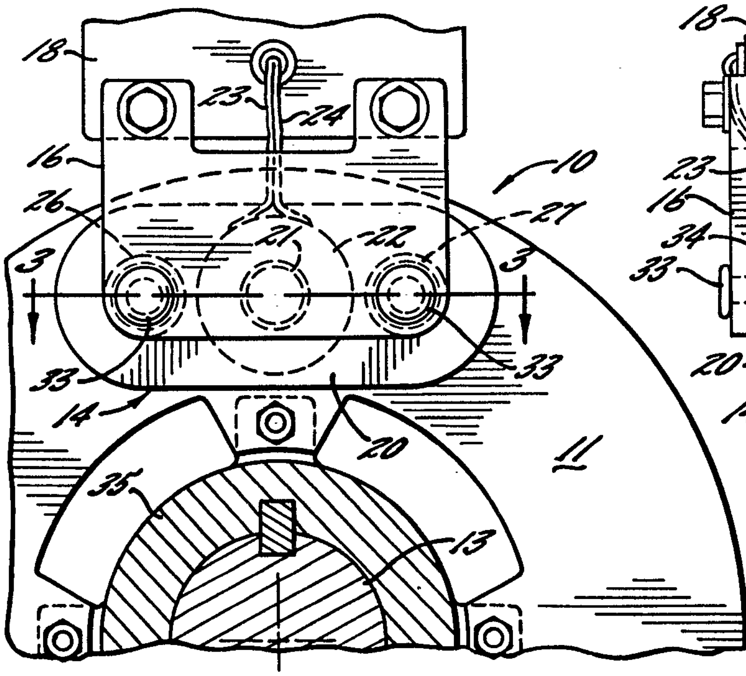

Fig. 1.

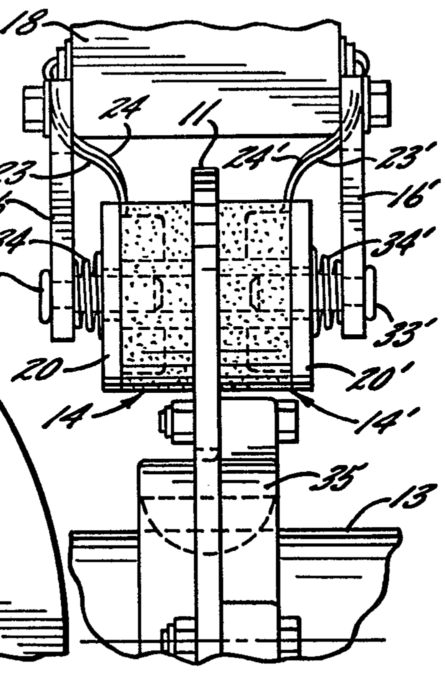

Fig. 2.

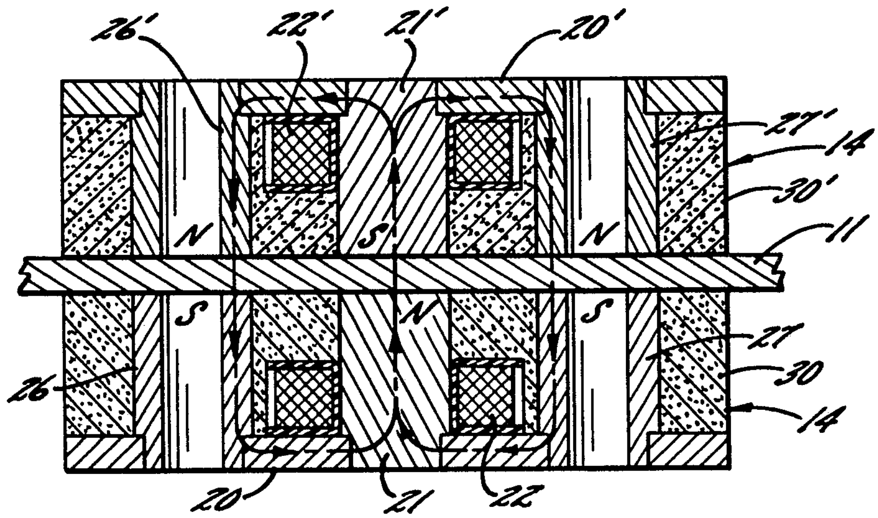

Fig. 3.

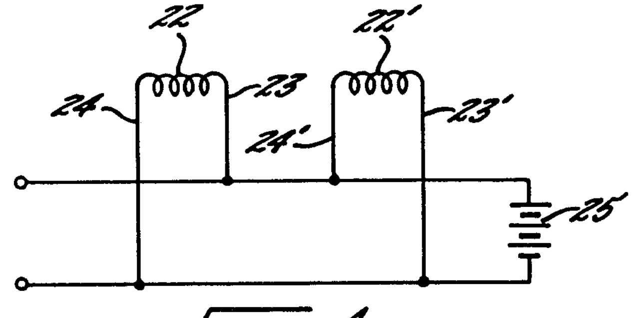

Fig. 4.

SPECIFICATION

Electromagnetic caliper brakes

The present invention relates to electromagnetic caliper brakes, that is braking apparatus of the type in which friction brakes engage opposite sides of a rotating armature to apply a braking force to the armature.

In one type of prior eletromagnetic caliper brake, the armature is formed by two side-by-side and substantially magnetically separate discs which rotate in unison. The discs are disposed between sets of electromagnetically actuated friction brakes which, when actuated, are magnetically drawn into frictional engagement with the sides of the discs. Each of the electromagnetic friction brakes comprises an electromagnet having at least two poles of opposite magnetic polarity. When each electromagnet is excited, magnetic flux cuts across an air gap between the disc and one of the poles, threads either radially or circumferentially through the disc and then cuts back across the gap to the other pole, the flux causing the brake to be drawn into frictional engagement with the disc. In a caliper brake of this type, there is no substantial interaction between the controlled flux paths of the two opposing electromagnetic friction brakes since the armature is formed by two substantially magnetically separate discs. Because the armature requires two discs, it is rather massive and therefore a large diameter armature possesses relatively high intertia.

Another proposed type of electromagnetic caliper brake has an armature which is a single disc disposed between a set of opposing friction brakes. Only one of the friction brakes, however, is directly magnetically actuated. When that brake (referred to as the master brake) is actuated and is magnetically drawn into frictional engagement with one side of the armature disc, flux threads axially through the disc to the other friction brake (referred to as the slave brake) and draws the latter brake into frictional engagement with the opposite side of the armature disc. In order to cause the flux to thread axially through the disc between the master brake and the slave brake, it is necessary to form arcuate slots in the armature disc between each set of poles of the master brake. The slots tend to weaken the structural integrity of the disc and, in addition, the slots must be formed at different radial locations in discs of different diameters.

The present invention provides an electromagnetic caliper brake comprising a rotary armature defined by a single disc made of low reluctance material, first and second electromagnets located on opposite axially facing sides of said disc, each of said electromagnets having first and second pole faces facing said disc, the first and second pole Laces of each electromagnet being in substantial alignment with the respective pole faces of the other electromagnet, means for exciting said first electromagnet to cause the first pole face thereof to be of one polarity and to cause the second pole face thereof to be of the opposite polarity, and means for exciting said second electromagnet to cause the first pole face thereof to be of said opposite polarity and to cause the second pole face thereof to be of said one polarity, whereby magnetic flux produced by said excited electromagnets threads a path extending from the first pole face of said first electromagnet and through said disc to the first pole face of said second electromagnet and thence from the second pole face of said second electromagnet and back through said disc to the second pole face of said first electromagnet.

The invention also provides an electromagnetic caliper brake comprising a rotary armature defined by a single disc made of low reluctance material, first and second electromagnets located on opposite axially facing sides of said disc, each of said electromagnets having first, second and third pole faces disposed in facing relation with said disc, the first, second and third pole faces of each electromagnet being in substantial alignment with the respective pole faces of the other electromagnet, means for exciting said first electromagnet to cause the first and third pole faces thereof to be of one polarity and to cause the second pole face thereof to be of the opposite polarity, and means for exciting said second electromagnet to cause the first and third pole faces thereof to be of said opposite polarity and to cause the second pole face thereof to be of said one polarity.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying diagrammatic drawings in which:

Figure 1 is a fragmentary side elevational view of an electromagnetic caliper brake;

Figure 2 is a fragmentary end view of the brake shown in Fig. 1;

Figure 3 is an enlarged fragmentary cross-section taken substantially along the line 3-3 of Fig. 1;

Figure 4 is a schematic view of the electrical circuit for energizing the electromagnets of the brake shown in Fig. 1.

As shown in the drawings for purposes of illustration, an electromagnetic caliper brake 10 is adapted to apply braking torque to a circular armature 11 which is secured to a rotatable shaft 13. Herein, the caliper brake comprises two electromagnetically actuated friction brakes 14 and 14'.

The electromagnetic friction brake 14 is secured to a mounting bracket 16 and is located on one side of the armature 11. The brake 14' is secured to an identical mounting bracket 16' and is located on the opposite side of the armature. Both mounting brackets are connected at their upper ends to an electrical connection box 18 located above the armature and adapted to be anchored to a fixed, rigid member (not shown). Thus, the brakes straddle the armature 11 and, when energized, the brakes engage opposite sides of the armature to retard or stop the shaft 13.

The brakes 14 and 14′ are identical and thus only the structure of the brake 14 will be described in detail. For simplicity, each brake has been shown herein as being generally similar to the brake disclosed in Figs. 8 and 9 of Myers et al United States Patent Specification No. 4,172,242. It should be understood, however, that each brake may be constructed in accordance with the teaching of Kroeger et al United States Patent Specification No. 4,344,056.

As shown in Fig. 3, the electromagnetic friction brake 14 comprises a flat, oblong plate 20 which may be stamped from steel or other sheet metal having low magnetic reluctance. A cylindrical stud 21 defining a magnetic pole of one polarity is fixed rigidly to the center of the plate and supports a coil 22. The coil is of well-known construction and comprises a multiturn winding having lead wires 23 and 24 (Fig. 2) which extend to the electrical box 18. The coil is adapted to be energized selectively by a suitable dc. voltage source 25 (Fig. 4) which is connected to the lead wires at the electrical box 18.

Located on opposite sides of the stud 21 are two additional cylindrical studs 26 and 27 defining magnetic poles which are of opposite polarity from the pole defined by the stud 21. The studs 26 and 27 also are fixed rigidly to the plate 20 and are spaced equidistantly from the stud 21. All of the studs are made of steel. The stud 21 is solid and the studs 26 and 27 are tubular.

The brake 14 is completed by an oblong block 30 of friction material which is bonded to the plate 20. Holes in the block 30 receive the studs 21, 26 and 27 while a cavity in the block accommodates the coil 22. The outer ends of the three studs are substantially flush with the flat outer face of the friction block.

Each of the brakes 14,14′ is supported on the respective mounting bracket 16,16′ by a pair of pins 33 (Figs. 1 and 2) which project slidably into the studs 26 and 27. Coil springs 34 are telescoped over the pins and are compressed between the mounting bracket 16 and the plate 20. The springs act to urge the friction block 30 of the brake into very light rubbing engagement with the armature 11.

The electromagnetic friction brake 14 is arranged to interact uniquely with the brake 14′ to enable the overall caliper brake 10 to produce relatively high braking torque and to enable the use of a single armature disc 11 which is comparatively thin in the axial direction and which need not be slotted or otherwise perforated. By virtue of being able to use a single, thin armature, the inertia of the armature is relatively low and thus less braking torque is required to stop the armature and more torque is available to stop the shaft 13. In addition, the cost of manufacturing armatures of different diameters is reduced since the armatures need not be slotted at different radial locations.

Herein, the armature 11 comprises a comparatively thin circular disc made of steel or other low reluctance material. The disc is bolted to a hub 35 which, in turn, is secured to the shaft 13. The center portion of the armature disc is formed with an opening to accommodate the hub 35 but the braking surface of the disc is solid and unperforated.

The friction brakes 14 and 14′ are disposed in opposing relationship to one another and are positioned such that the poles 21, 26 and 27 of the brake 14 are aligned radially and circumferentially with the poles 21′,26′ and 27′, respectively, of the brake 14′. When the coils 22 and 22′ are energized, the magnetic flux which is produced causes the brakes 14 and 14′ to be magnetically attracted to the armature 11. The brakes thus are shifted along the pins 33 and toward the armature to cause the friction blocks 30 to tightly engage the armature and apply braking torque thereto.

During braking, the coils 22 and 22′ of the two brakes 14 and 14′ are energized such that the poles of one brake are of opposite magnetic polarity from the aligned poles of the other brake. As a result, the magnetic flux not only causes the two brakes to be attracted to the armature 11 but also causes the brakes to be attracted to one another so as to increase the breaking torque over and above the maximum torque which could be achieved by the two brakes acting separately.

In the present instance, polarization of the poles 21, 26 and 27 of the brake 14 oppositely from the poles 21′, 26′ and 27′ of the brake 14′ is effected by connecting the coil 22 of the brake 14 to the dc voltage source 25 in reverse fashion with respect to the connection of the coil 22′ of the brake 14′ to the voltage source. For example, and assuming that the windings of the two coils are wound in the same direction, the lead wire 23 of the coil 22 is connected to the positive side of the voltage source 25 while the corresponding lead wire 23′ of the coil 22′ is connected to the negative side of the voltage source (see Fig.4). Conversely, the lead wires 24 and 24′ of the coils 22 and 22′ are connected to the negative and positive sides, respectively, of the voltage source.

With the foregoing arrangement, it may be assumed that the center pole 21 of the brake 14 constitutes a "north" pole while the two outer poles 26 and 27 of the brake 14 constitute "south" poles. Because the brake 14' is of opposite polarity, its center pole 21' is a "south" pole and its two outer poles 26' and 27' are "north" poles.

When the coils 22 and 22' are energized, magnetic flux is produced by both coils. As shown in Fig.3, the flux produced by the coil 22 of the brake 14 threads out of the "north" pole 21 and passes axially through the armature 11 to the "south" pole 21' of the brake 14' and then to the plate 20' of that brake. At the plate 20', the flux splits into two paths with the flux of each path threading out of the "north" pole 26' or 27' of the brake 14', axially back through the armature 11, into the "south" pole 26 or 27 of the brake 14, through the plate 20 of that brake and thence back to the "north" pole 21. At the same time, the flux produced by the coil 22' threads paths which coincide with the paths followed by the flux produced by the coil 22. That is, the flux produced by the coil 22' threads out of each "north" pole 26', 27' of the brake 14', across the armature 11 to the aligned south poles 26,27 of the brake 14 and then to the plate 20 of that brake. Such flux then flows to the "north" pole 21 of the brake 14, then back across the armature 11 to the "south" pole 21' of the brake 14' and finally along two paths through the plate 20' of that brake and back to the "north" poles 26' and 27'.

Thus, the flux produced by each brake 14,14' passes axially across the armature 11 and through the other brake such that there is an interaction of the flux of the two brakes. Each brake, therefore, is not only attracted to the armature 11 by its own flux but is also attracted to the armature by the flux of the other brake. This interaction of the flux enables the brakes to produce greater torque than would be possible if the two brakes were acting entirely independently of one another. Moreover, the armature transmits the flux axially between the brakes and need not be formed either by a thick disc or by spaced discs for the purpose of isolating the flux of one brake from the flux of the other braKe. Accordingly, the inertia of the thin armature is relatively low. In addition, the armature does not require slots for determining the proper flux paths and thus the armature not only is structurally strong but also armatures of all diameters may be manufactured in an economical manner when compared with slotted armatures.

CLAIMS

1. An electromagnetic cali per brake comprising a rotary armature defined by a single disc made of low reluctance material first and second electromagnets located on opposite axially facing sides of said disc, each of said electromagnets having first and second pole faces facing said disc, the first and second pole faces of each electromagnet being in substantial alignment with the respective pole faces of the other electromagnet, means for exciting said first electromagnet to cause the first pole face thereof to be of one polarity and to cause the second pole face thereof to be of the opposite polarity, and means for exciting said second electromagnet to cause the first pole face thereof to be of said opposite polarity and to cause the second pole face thereof to be of said one polarity, whereby magnetic flux produced by said excited electromagnets threads a path extending from the first pole face of said first electromagnet and through said disc to the first pole face of said second electromagnet and thence from the second pole face of said second electromagnet and back through said disc to the second pole face of said first electromagnet.

2. A brake as claimed in claim 1, wherein said armature disc is an axially, relatively thin, unperforate disc.

3. A brake as claimed in claim 1 or 2, wherein each electromagnet includes a third pole face, the third pole faces being aligned.

4. A brake as claimed in claim 3, wherein the first and third pole faces of said first electromagnet are "north" poles, and the first and third pole faces of said second electromagnet are "south" poles.

5. An electromagnetic caliper brake comprising a rotary armature defined by a single disc made of low reluctance material, first and second electromagnets located on opposite axially facing sides of said disc, each of said electromagnets having first, second and third pole faces disposed in facing relation with said disc, the first, second and third pole faces of each electromagnet being in substantial alignment with the respective pole faces of the other electromagnet, means for exciting said first electromagnet to cause the first and third pole faces thereof to be of one polarity and to cause the second pole face thereof to be of the opposite polarity, and means for exciting said second electromagnet to cause the first and third pole faces thereof to be of said opposite polarity and to cause the second pole face thereof to be of said one polarity.

6. An electromagnetic caliper brake substantially as herein described with reference to the accompanying drawings.

Printed in the United Kingdom for
Her Majesty's Stationery Office, Dd 8818935, 1984, 4235.
Published at The Patent Office, 25 Southampton Buildings,
London, WC2A 1AY, from which copies may be obtained.