

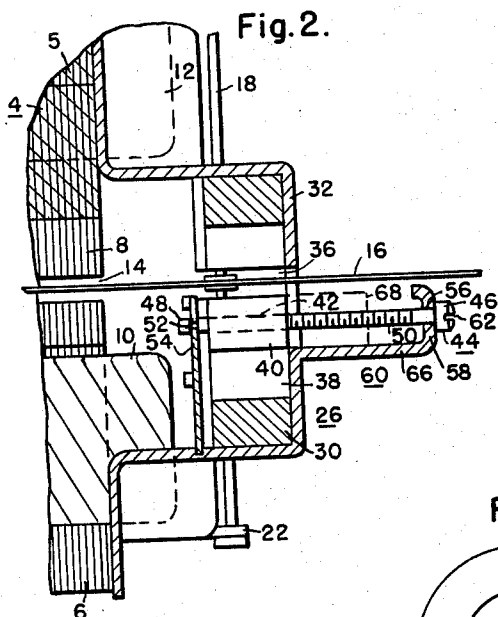
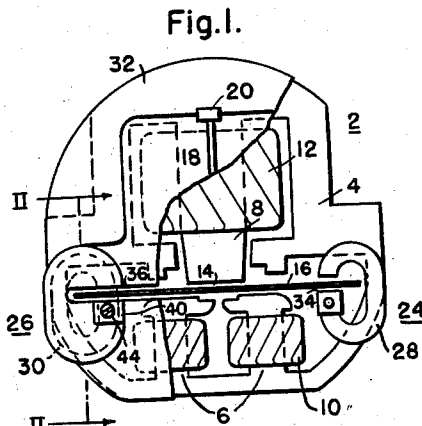
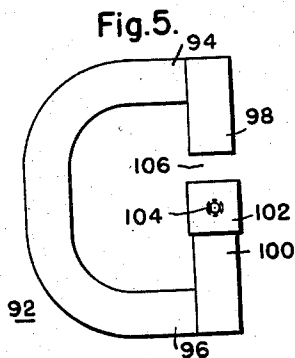
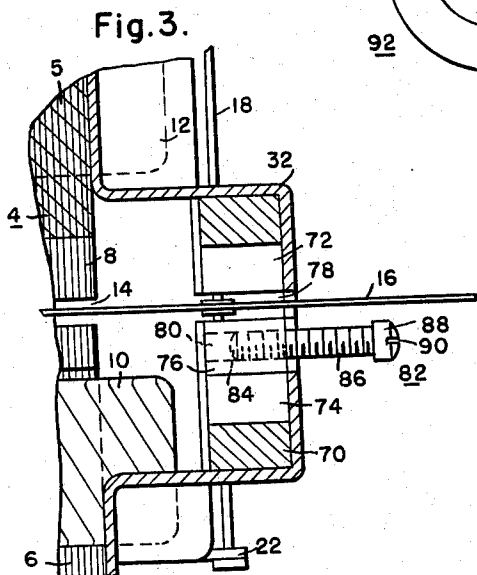
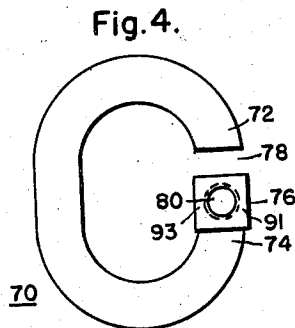
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MAGNETIC ASSEMBLY

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MAGNETIC ASSEMBLY

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This invention relates to magnetic assemblies, and more particularly, to adjustable magnetic damping assemblies for induction disc-type instruments.

Various instruments, such as integrating watt-hour meters, power relays, and the like, operate on the induction motor principle, whereby a suitable armature member, which may be in the form of an electroconductive disc, is mounted for rotation under the influence of displaced alternating magnetic fields to produce a response representative of conditions of an electrical circuit. The disc armature is commonly carried by a shaft which is mounted for rotation in suitable bearings, and consequently, would tend to rotate at a relatively high rate of speed if damping means were not provided.

In order to maintain the rotational speed of disc armatures within practical limits, induction disc-type instruments have been provided with permanent magnet damping assemblies. Such an assembly may comprise one or more permanent magnets constructed of a suitable high coercive magnetic material, such as Alnico, and being of substantially C-shaped configuration to have a pair of opposed poles spaced to define an air gap. If a pair of magnets are employed they may be mounted relative to the disc armature so that portions of the disc pass through the air gaps during rotation thereof. As the disc rotates, eddy currents are produced in the portions thereof which cut the magnetic flux lines traversing the air gaps of the magnets. These eddy currents produce magnetic flux lines which, in turn, react with the flux lines of the magnets to effect the desired damping of the disc.

In order to provide an adjustable damping effect, it has been the practice to mount an adjustable magnetic shunt for movement relative to the air gap of the associated magnet to shunt an adjustable amount of flux away from the air gap, thereby controlling the damping effect of the magnetic assembly.

In accordance with the invention, a series type of damping adjustment is provided in order to eliminate certain disadvantages, characteristic of the above-described adjustable shunt damping assemblies. The series reluctance of the magnetic circuit defined by a substantially C-shaped permanent magnet is controlled by providing a magnetic member mounted for movement relative to the magnet to alter the effective length of the associated air gap. The magnetic member conveniently may be in the form of an adjustable pole piece for one of the poles of the C-shaped magnet with suitable adjusting means being provided to effect the desired movement of the pole piece. For example, the pole piece adjusting means may conveniently comprise a threaded screw member extending through a suitably threaded aperture of the pole piece, the end portions of the screw being positioned in suitable bearings to mount the screw for rotational movement without substantial axial movement.

In a preferred embodiment of the invention a meter having an electroconductive disc or armature mounted for rotation is provided with two C-shaped permanent magnets of high-coercive material located substantially

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in a common plane. This plane is parallel to the axis of rotation of the disc and contains, or is adjacent to, such axis. Preferably at least one of the permanent magnets is provided with a pole piece having an adjusting unit which is operable in a direction substantially transverse to the aforesaid plane for the purpose of adjusting the damping torque of the meter.

The damping magnets desirably may be located in a frame of electroconductive material. The frame conveniently provides a support for the adjusting unit and bearing supports for the disc.

A modification of the invention contemplates that the series reluctance of the magnetic circuit of at least one of the C-shaped permanent magnets may be controlled by providing a pole piece which is permanently affixed to one of the poles of the magnet, the pole piece being provided with an aperture for adjustably receiving an insert formed of a magnetic material of high permeability such as steel. For example, the pole piece aperture may be threaded to adjustably receive a steel screw member for controlling the reluctance of the associated magnetic circuit.

It is, therefore, an object of the invention to provide a magnetic assembly with improved means for controlling the operation thereof.

It is another object of the invention to provide a magnetic assembly including a C-shaped permanent magnet of high-coercive material having an adjustment for varying the series reluctance of the magnetic path defined by the magnet.

It is still another object of the invention to provide a magnetic assembly including a C-shaped permanent magnet of high-coercive material with an adjustable magnetic member mounted for movement in a direction transverse to the plane of the magnet for varying the series reluctance of the magnetic path defined by the magnet.

It is a further object of the invention to provide a magnetic damping assembly for induction disc-type instruments including a C-shaped permanent magnet of high-coercive material having a pair of opposed poles defining an air gap with an adjustable pole piece mounted for movement in a direction transverse to the plane of the magnet for varying the series reluctance of the magnetic path defined by the magnet, air gap and pole piece.

It is a still further object of the invention to provide an induction disc-type instrument including a supporting frame member of non-magnetic, electroconductive material formed with pockets proportioned to receive C-shaped damping magnets which may be secured in position within the pocket.

It is another object of the invention to provide an induction disc-type instrument having damping magnets which may be magnetized prior to mounting thereof in operative position.

It is a further object of the invention to provide an instrument including a frame member of non-magnetic, electroconductive material adapted to support a disc armature for rotation about an axis and formed with spaced pockets proportioned and positioned to receive C-shaped disc-damping magnets for mounting the magnets substantially in a plane containing the axis, the instrument having an adjustment including a magnetic member and means mounting the magnetic member on the frame member for adjustment in a direction transverse to the plane of the magnets for varying the damping action thereof.

Other objects of the invention will be apparent from the following description, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a view in front elevation with parts broken away of an electrical measuring instrument embodying the invention;

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Fig. 2 is an enlarged sectional view taken along the line II—II of Fig. 1;

Fig. 3 is a view similar to Fig. 2 showing a modification of the invention;

Fig. 4 is a view in front elevation of a permanent damping magnet suitable for use with the device of Fig. 3; and

Fig. 5 is a view similar to Fig. 4 of a permanent damping magnet suitable for use with the devices of Figs. 1, 2 and 3.

Referring to Fig. 1, there is disclosed an electrical measuring instrument 2 of the induction disc-type. For purposes of the invention, it will be assumed that the instrument 2 is an integrating watt-hour meter responsive to energy flowing in a single phase alternating-current circuit (not shown). The instrument 2 may include a magnetic structure 4 constructed of a plurality of laminations 5 of a suitable magnetic material, such as steel, disposed in stacked relation to provide a pair of spaced current poles 6 and a single voltage pole 8. The current poles 6 and the voltage pole 8 are provided with windings 10 and 12, respectively, and are preferably positioned relative to one another to have the pole faces thereof spaced to provide an air gap 14. The windings 10 of the current poles 6 may be connected for energization in accordance with current flowing in an alternating-current circuit (not shown). In a similar manner, the windings 12 of the voltage pole 8 may be connected for energization in accordance with voltage of an alternating-current circuit (not shown). With connections properly made, energization of windings 10 and 12 is effective to produce displaced alternating magnetic fluxes in the air gap 14.

In order to produce a response representative of energy flowing in an alternating-current circuit (not shown), the instrument 2 is provided with an electroconductive disc 16 affixed to a shaft 18 which is mounted for rotation relative to the magnetic structure 4 in suitable upper and lower bearings 20 and 22. As shown, the disc 16 is positioned relative to the structure 4 to rotate through the air gap 14 under the influence of the displaced alternating magnetic fluxes traversing the air gap. For the purpose of maintaining the rotational speed of the disc 16 within practical limits, magnetic damping assemblies 24 and 26 are provided. The pair of magnetic assemblies 24 and 26 may conveniently comprise a pair of substantially C-shaped permanent magnets 28 and 30 respectively, constructed of suitable magnetic material of high coercive force, such as Alnico. The magnets 28 and 30 may be positioned relative to the disc 16 in any desired manner. For example, the magnets may be die-cast into a disc-supporting frame 32 of a suitable non-magnetic, conducting, die-casting material such as an aluminum alloy. Preferably, however, the frame 32 is die-cast with suitable pockets proportioned to receive the magnets through open ends of the pockets, the magnets being retained within the pockets in any suitable manner such as by a staking operation. The magnets may conveniently be magnetized prior to insertion thereof into the pockets. The frame 32 is adapted to support the magnetic structure 4 together with the shaft 18 and disc 16.

In order to mount the disc 16 for rotation, the frame 32 may be formed with suitable spaced bearing means 20 and 22 which receive the ends of the shaft 18. As shown the magnets 28 and 30 each have a pair of opposed poles which may be provided with suitable pole pieces, as will appear hereinafter, to define air gaps 34 and 36, respectively. The pockets of the frame 32 are positioned to mount the magnets so that air gaps 14, 34 and 36 are substantially in alignment to thereby permit rotation of the disc 16 through such air gaps. Magnetic fluxes traversing the separate magnetic circuits provided by the magnet 28 and the air gap 34 and the magnet 30 and the air gap 36 produce in the rotating disc 16 eddy

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currents which, in turn, produce magnetic fluxes which react with the magnetic fluxes of the magnets 28 and 30 to retard rotation of the disc 16.

As previously pointed out, the permanent magnets preferably are constructed of a high-coercive material, such as one having a coercive force in excess of 200 oersteds. A number of materials of this type are available. For example, high-cobalt permanent magnet steel, such as one containing 36% by weight of cobalt is available. In a preferred embodiment of the invention a high-coercive alloy of aluminum-nickel-cobalt, known as Alnico, is employed. These high-coercive alloys provide compact permanent magnets and have good resistance to demagnetization.

High-coercive magnets have been employed in the past, but the provision of adequate adjustment ranges for the magnets has been a serious problem. One proposed solution has involved the provision of a shunt. However, such a shunt has not been effective in providing a reasonably satisfactory range of adjustment and it has been necessary to construct equipment employing such shunt-adjusted magnets within an undesirably small tolerance.

It has also been proposed that a high-coercive horseshoe magnet be associated with a multipart armature. Such an assembly occupies appreciable space and has a large number of parts.

In order to provide an adjustable damping effect, one or both of the magnets 28 and 30 may be provided with adjustable means effective to vary the amount of flux traversing the associated air gap for controlling the rotational speed of the disc 16. In the past, adjustable damping has been effected by providing a shunt path which is adjustable relative to the air gap defined by the poles of the associated permanent magnet. These shunt paths are commonly in the form of a piece of iron or other magnetic material which is mounted for movement toward and away from the associated air gap to effect the shunting of more or less of the magnetic flux traversing the air gap for controlling the damping action. Considerable difficulty has been experienced in providing an adjustable damping assembly of the shunt type having both a high degree of sensitivity and small physical dimensions, the reason being that in order to effectively shunt a relatively large amount of magnetic flux away from the air gap the shunt member should be of relatively large cross-sectional area and of relatively long length to avoid magnetic saturation.

In accordance with the invention a series type of adjustment controls the reluctance of the magnetic damping circuit. Referring to Figs. 1 and 2, there is disclosed a preferred form of series-type damping adjustment whereby the reluctance of the magnetic damping circuit is effectively controlled to provide a corresponding control of the magnetic damping of the disc 16. As there shown, the magnet 30 and the associated air gap 36 provide a magnetic circuit for magnetic damping flux. As is clearly shown in Fig. 2, the disc 16 is mounted for rotation under the influence of the magnetic flux of the magnet 30 to be damped thereby in the manner previously described. In order to provide for adjustable damping of the disc 16, the magnet 30 is provided with control means in the form of a soft iron pole piece 40 for the pole 38 which is mounted for movement relative to the air gap 36 to vary the effective length of the air gap and, consequently, to control the damping provided by the magnet 30. The pole piece 40 is preferably provided with a threaded aperture 42 which extends entirely through the pole piece, as shown in Fig. 2, to receive an insert or adjusting member 44 of any desired material. Preferably, the member 44 is constructed of a non-magnetic material such as brass and is in the form of a screw member having a head 46, a point 48 and a threaded stem 50.

For the purpose of mounting the screw member 44 for

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rotational movement without substantial axial movement to effect displacement of the pole piece 40 axially of the screw member, suitable support members 54 and 60 are provided. The support member 54 is secured to the frame 32 and is provided with bearing means in the form of a slot 52 disposed to receive the point 48 of the screw 44 which extends through the aperture 42 of the pole piece 40. The screw may be provided with a portion of reduced diameter for receiving portions of the side walls of the bearing slot 52 for the purpose of holding the screw against axial movement. The portion of the stem 50 adjacent the head 46 of the screw engages bearing means in the form of an aperture 56 in an arm 58 of the support member 60 with the head 46 of the screw being in engagement with the arm 58. Rotation of the screw member 44 relative to the supports 54 and 60 operates to effect displacement of the pole piece 40 axially of the screw member inasmuch as axial movement of the screw member is prevented by means of the support members 54 and 60. To assure proper seating of the pole piece 40 on the pole face of the pole 38, the bearing means 52 and 56 should be proportioned to provide a certain amount of vertical clearance for portions of the screw 44 engaging the bearing means. Magnetic attraction between the pole piece 40 and the pole 38 affords protection against accidental displacement of the pole piece 40.

In order to effect rotation of the screw 44 for moving the pole piece 40 relative to the air gap 36, the head 46 of the screw may be recessed to provide a slot 62 for receiving a suitable tool, such as a screw driver. For the purpose of supporting the pole piece 40 in various positions of adjustment thereof, the support member 60 may include a table portion 66 having a surface substantially in alignment with the pole face of the pole 38 as shown in Fig. 2. The operation of the adjustable damping device may now be described as follows.

Assuming the pole piece 40 to be positioned as shown in Fig. 2, and assuming the disc 16 to be rotating at a speed slightly less than the speed required to produce a response representative of energy of the associated circuit (not shown), then the speed of the disc 16 may be increased to approach the proper value by effecting rotation of the screw 44 in the direction to move the pole piece 40 away from the air gap 36 onto the table portion 66 of the support 60. Rotation of the screw 44 may be effected in any desired manner. Conveniently, a suitable tool, such as a screw driver, may be inserted into the slot 62 to effect such rotation. The screw member 44 is adjusted in the manner described until the speed of the disc 16 has been increased to a value which produces a response truly representative of the energy of the associated circuit (not shown). Movement of the pole piece 40 away from the air gap 36 operates to increase the effective length of the air gap to thereby effect a corresponding increase in the reluctance of the associated magnetic circuit whereby the amount of flux traversing the air gap 36 and cutting the disc 16 is decreased.

Assuming now that the disc is rotating at a speed slightly in excess of the speed necessary to produce a response representative of energy flowing in the associated circuit (not shown) and that the pole piece 40 is in the position represented by the dotted line 68, then the speed of the disc 16 may be reduced to the proper value, by inserting a tool into the slot 62 and rotating the tool in the direction to effect movement of the pole piece 40 along the table 66 toward the air gap 36. The effect of movement of the pole piece 40 in the manner described is opposite to the effect thereof in the preceding situation; that is, movement of the pole piece 40 toward the air gap 36 operates to decrease the effective length of the air gap to thereby effect a corresponding decrease in the reluctance of the associated magnetic circuit whereby the amount of magnetic flux traversing the air gap 36 and cutting the disc 16 is increased. By proper selection of

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materials and physical dimensions of the pole piece 40 and the core 30, a very sensitive damping adjustment may be provided. It is to be understood that the invention is not limited to the provision of adjusting means 44 in the form of a screw member but that any suitable type of adjuster may be utilized to effect movement of the pole piece 40.

The magnet-receiving pockets of the frame 32 are preferably positioned to mount the magnets 28 and 30 substantially in a common plane which may contain the axis of rotation of the disc 16 or which may be adjacent and parallel to such axis. The small C-shaped magnets are located substantially on opposite sides of the axis.

The adjustments previously described are effected by movement of a magnetic member in a direction substantially transverse to the plane of the magnets. Consequently, operation of the magnetic member does not appreciably change the radial distance of the damping flux from the axis of rotation of the disc 16. In addition, the adjustments are readily made from the front of the meter.

Referring now to Figs. 3 and 4, there is shown another embodiment of the invention wherein the reluctance of a magnetic damping circuit is controlled by varying the magnetic saturation characteristics of a pole piece constituting a portion of the magnetic circuit. As there shown, a permanent magnet 70 similar to the magnets 28 and 30 of Figs. 1 and 2 is provided. The magnet 70 may be constructed of a suitable high coercive magnetic material, such as Alnico, and is provided with a pair of spaced opposed poles 72 and 74. If desired, a pair of the magnets 70 may be provided for the instrument 2.

In order to provide for an effective series damping assembly, a soft iron pole piece 76 may be permanently secured to the pole 74 of the magnets 70 to define an air gap 78 with the pole 72. The pole piece 76 is preferably provided with an aperture 80 having a diameter sufficiently large to snugly receive insert means 82 constructed of a soft magnetic material, such as steel, and suitable for adjustment within the aperture 80. The aperture 80 defines magnetic bridge portions 91 and 93 of the pole piece 76 which saturate for low values of magnetic flux. In a preferred form of the invention the aperture 80 is threaded to adjustably receive insert means comprising a screw member having a point 84, a threaded stem 86 and a head 88. It is to be understood that the invention is not limited to the provision of insert means in the form of a screw member but that any suitable type of magnetic insert means may be provided for the aperture 80, such as a plug of soft iron or steel suitable for manual or mechanical adjustment axially of the aperture 80. In order to provide an adjustable magnetic damping effect, the head 88 of the screw member is preferably recessed to provide a slot 90 for the reception of a suitable tool, such as a screw driver, to effect rotation of the screw member relative to the aperture 80. The operation of the device of Figs. 3 and 4 may now be described as follows.

Assuming the screw member 82 to be in the position shown in Fig. 3 and assuming the disc 16 to be rotating at a speed slightly in excess of the speed necessary to provide a true representation of the energy flowing in the associated circuit (not shown), then the speed of the disc 16 may be reduced to the desired value by inserting a tool into the slot 90 and rotating it in the direction for advancing the screw member 82 along the aperture 80 to a position in which the screw 82 occupies a somewhat larger portion of the aperture 80 than is occupied thereby in the position shown in Fig. 3. The effect of such movement of the screw 82 is to shunt magnetic flux around bridges 91 and 93 thereby decreasing the reluctance of the associated magnetic circuit and increasing the amount of magnetic flux traversing the air gap 78 and cutting the disc 16.

Assuming the disc 16 to be rotating at a speed slightly

less than the speed which produces a response representative of energy flowing in the associated circuit (not shown) and assuming the screw member 82 to be in the position shown in Fig. 3, then the speed of the disc 16 may be increased to approach the proper value by effecting rotation of the screw member 82 in the direction to effect the withdrawal thereof from the aperture 80 to a position in which the screw 82 occupies a somewhat smaller portion of the aperture 80 than is occupied by the screw 82 in the position shown in Fig. 3. Movement of the screw 82 in the manner described operates to decrease the amount of flux shunted around bridges 91 and 93 to thereby increase the reluctance of the associated magnetic circuit and decrease the amount of magnetic flux traversing the air gap 78 and cutting the disc 16. By selecting an insert member of proper dimensions and material, the adjustment effected by means of the invention illustrated in Figs. 3 and 4 may be rendered extremely sensitive and accurate. It is to be noted that the magnitudes of the cross-sectional areas of the aperture 80 and the insert means 82 may have a substantial effect upon the amount of adjustment required to correct the speed of the disc 16. For this reason the diameters of the aperture and the insert means should be made as large as possible to provide an adjustment of maximum sensitivity.

With reference to Fig. 5, there is illustrated a permanent magnet 92 constructed of suitable magnetic material, such as Alnico, and having a pair of poles 94 and 96. A pair of the magnets 92 may be utilized in the device of Fig. 1 in place of the magnets 28 and 30 or in place of a pair of the magnets 70. In order to provide a very sensitive damping adjustment, one of the magnets 92 may be provided with pole pieces 98 and 100 permanently affixed to the poles 94 and 96, respectively, and an additional pole piece 102 having an aperture 104 may be provided for the pole piece 100 to define an air gap 106 with pole piece 98. The pole piece 102 may be either movably mounted or permanently affixed on the pole piece 100 depending upon the utilization of the magnet 92. If the magnet 92 is utilized in the device of Figs. 1 and 2 the pole piece 102 may be movably mounted on the pole piece 100 in the same manner by which the pole piece 40 is mounted on the pole 38. If the magnet 92 is utilized in the device of Fig. 3, the pole piece 102 may be omitted entirely with the pole piece 100 being provided with an opening and increased in length to provide an air gap of proper dimensions. Provision of the pole pieces 98 and 100 is effective to concentrate the magnetic flux to produce a high flux density in portions of the associated magnetic circuit. Consequently, slight adjustment of the magnetic control means is effective to produce a large variation in damping effect.

Since certain changes may be made in the above construction, and different embodiments of the invention may be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. A magnetic assembly for damping rotation of an induction disc including a substantially C-shaped permanent magnet formed of material having a coercive force of at least two hundred oersteds, said magnet having a pair of opposed poles with pole faces, an adjustable pole piece for one of the poles having a face defining an air gap with the face of the other of said poles proportioned to receive a portion of the disc, said magnet, pole piece and air gap defining a magnetic circuit disposed in a loop, said pole piece having a threaded opening extending entirely therethrough along a first axis transverse to the plane of the loop, a screw member in threaded engagement with said opening, and support means including bearing means mounting the screw member for rotation about the first axis without sub-

stantial axial movement to effect adjustment of the pole piece relative to the magnet along the first axis to vary the reluctance of the magnetic circuit.

2. In an electrical device, an iron magnetic structure including spaced first magnetic poles defining a first air gap, winding means surrounding the first poles effective when energized for establishing a shifting magnetic field in the first air gap, electroconductive frame means formed with a cup-shaped pocket having an open end opening toward the magnetic structure, an armature mounted by the frame means for rotation about a first axis through the first air gap relative to the magnetic structure under the influence of the magnetic field, and a substantially C-shaped permanent magnet having a pair of second magnetic poles with pole faces lying in spaced parallel planes to define a second air gap, said pocket open end being proportioned to permit entry of the magnet therethrough in a direction substantially parallel to said pole faces from a position external to the pocket to a position substantially within the pocket, said magnet being positioned within the pocket with said first and second air gaps in alignment to permit passage of the armature through the second air gap, said magnetic structure being mounted by the frame means to substantially close the pocket open end.

3. In an electrical device, an iron magnetic structure including spaced first magnetic poles defining a first air gap, winding means surrounding the first poles effective when energized for establishing a shifting magnetic field in the first air gap, electroconductive frame means formed with a cup-shaped pocket having an open end opening toward the magnetic structure, an armature mounted by the frame means for rotation about a first axis through the first air gap relative to the magnetic structure under the influence of the magnetic field, a substantially C-shaped permanent magnet having a pair of second magnetic poles with pole faces lying in spaced parallel planes to define a second air gap, said pocket open end being proportioned to permit entry of the magnet therethrough in a direction substantially parallel to said pole faces from a position external to the pocket to a position substantially within the pocket, said magnet being positioned within the pocket with said first and second air gaps in alignment to permit passage of the armature through the second air gap, said magnetic structure being mounted by the frame means to substantially close the pocket open end, an adjustable magnetic member in engagement with said magnet, said magnet, second air gap and magnetic member defining a series magnetic circuit for flux of the magnet, and means including the frame means mounting the magnetic member for adjustment relative to the magnet in the direction parallel to said pole faces to vary the series reluctance of the magnetic circuit.

4. A magnetic damping assembly for damping rotation of an induction disc including a substantially C-shaped permanent magnet formed of material having a coercive force of at least two hundred oersteds, said magnet having a pair of spaced parallel side faces and a pair of opposed magnetic poles with first pole faces lying in spaced parallel planes transverse to said side faces, an adjustable magnetic block positioned in sliding contact with one of the first pole faces, said block having a second face defining an air gap with the first face of the other of the poles through which a portion of the disc is adapted to rotate, said second face having a dimension extending substantially transverse to said side faces which is at least equal to the spacing between the side faces, said magnet, block and air gap defining a magnetic circuit for flux of the magnet, and adjusting means operable to effect adjustment of the block for varying the reluctance of the magnetic circuit, said adjusting means including an actuatable portion located externally of the space between planes which include said side faces to permit adjustment of the block relative to the magnet

along an axis extending substantially transverse to said side faces.

2,149,885
2,349,347
2,595,244

References Cited in the file of this patent

UNITED STATES PATENTS

5

1,332,464 Harris ----- Mar. 2, 1920
1,920,818 Verrall ----- Aug. 1, 1933

272,236
290,981
453,262

Green ----- Mar. 7, 1939
Green ----- May 23, 1944
Goss ----- May 6, 1952

FOREIGN PATENTS

Germany ----- Mar. 27, 1914
Germany ----- Mar. 27, 1916
Great Britain ----- Sept. 8, 1936