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REGULATOR

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Fig. 1.

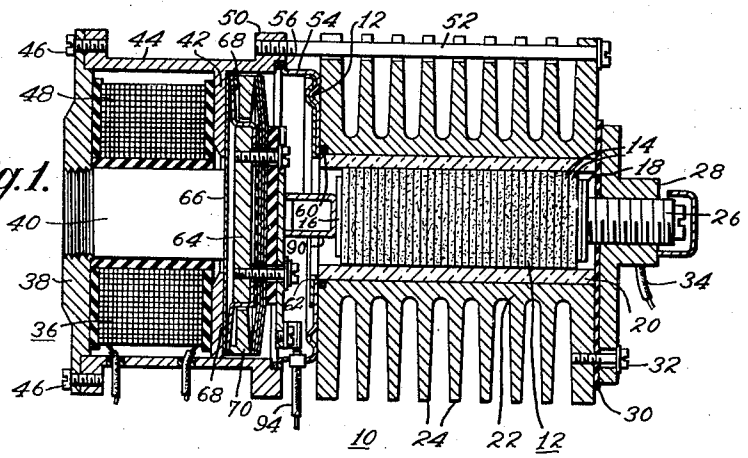
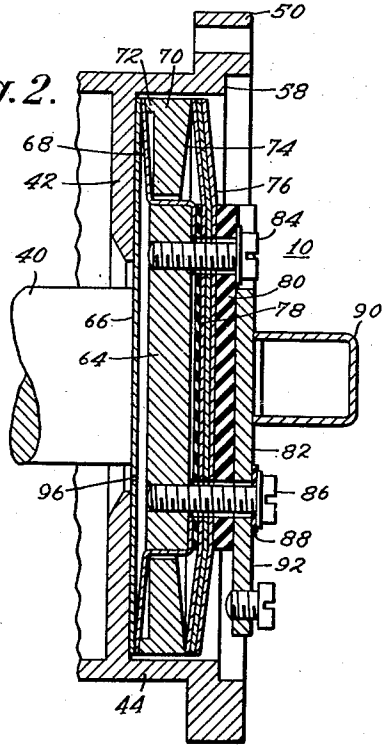


Fig. 2.



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REGULATOR

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11 Claims. (Cl. 201—51)

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This invention relates to regulators and, in particular, to regulators of the carbon-pile type.

Recently, there has been developed a lightweight regulator of the carbon-pile type in which the compression of the pile is varied by a magnet operating against a spring arrangement which is advantageously devised so that its characteristic is substantially matched with the magnetomotive force characteristic. Such regulators and improvements thereon have found wide use in certain applications where weight is a consideration.

Although these regulators are desirable from a weight viewpoint, and because of their matched spring versus magnetomotive force characteristic, it has been found that they become unstable with a very slight change from the original setting of the regulator with the result that unsatisfactory voltage regulation is obtained. For example, where the regulators are employed as voltage regulators for generators, if a sudden change in load on the generator is encountered, the armature member of the unit oscillates to give an unstable regulation. As the regulators are quite compact, and size and weight are essential considerations, it has heretofore been found to be impractical to stabilize the regulator without greatly adding to the weight, cost, and size of the unit.

An object of this invention is to provide a regulator of the pile type having a construction for effecting damping without increasing the size of the regulator or substantially increasing the weight of the regulator.

Another object of this invention is to utilize the air gap between the core member and the armature member of an electromagnet employed in conjunction with a pile in a regulator to provide damping for the regulator.

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

Figure 1 is a view in elevation and partly in section of a pile regulator embodying the teachings of this invention; and

Fig. 2 is a view greatly enlarged of a part of the construction shown in Fig. 1.

Referring to Figure 1 of the drawing, there is illustrated a regulator 10 of the pile type, having a stack 12 of disks 14 of high-resistance material, such as carbon or the like. The disks 14 are mounted between pressure plates 16 and 18 in a ceramic tube or sleeve 20 maintained in a jacket 22 of aluminum or the like, which is provided with fins 24 for dissipating heat from the stack.

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The pressure plate 18 is considered as a stationary plate being maintained in operating position by the adjustable screw 26 which projects through an end plate 28 that is insulated from the jacket 22 by the washer 30 of insulating material and held in position by a screw 32. As illustrated, a lead 34 is connected to the end plate 28 in any suitable manner, it being noted that the end plate 28, adjustable screw 26, pressure plate 18, and the disks 14 are maintained in good electrical conducting relation to one another.

At the opposite end of the stack 12, an electromagnet 36 is disposed for controlling the pressure applied to the stack. The electromagnet 36 comprises an end plate 38 and a central core member 40 threaded therein and an annular pole 42 carried by a body 44 which is secured to the end plate by screws 46 to enclose an energizing winding 48. The pole faces of the central core member 40 and the annular pole 42 are in substantially the same plane, it being noted that the body 44 extends beyond the annular pole 42 and terminates in a flange member 50.

The jacket 22 is mounted relative to the electromagnet 36 by means of spaced bolts 52, only one of which is illustrated, and a dust cap 54 is utilized to seal the moving parts of the regulator from the atmosphere. As illustrated, the dust cap 54 is an annular cup-shaped member having one edge seating against a ring seal 56 positioned in a groove 58 at the end of the body 44, the other edge being disposed to seat against a ring seal 60 carried in a groove in the jacket 22. A spring clip 62 having a substantially clover-leaf shape is disposed adjacent the dust cap 54 to strengthen the dust cap and to project against the end of the ceramic sleeve 20 to maintain the sleeve in its insulating position with respect to the jacket 22.

Referring to Fig. 2 of the drawing, the armature and spring assembly for the regulator is more clearly illustrated and, as shown, comprises an armature member 64 of substantially disk shape disposed in spaced relation to the core member 40 and the annular pole 42. In the embodiment illustrated, a thin disk 66 of magnetizable material is disposed over the annular pole 42 and the face of the core member 40 in the air gap between the core member 40 and the armature member 64. The thin disk 66 is preferably of steel having a thickness ranging between .002 and .004 of an inch so that it will readily saturate and not interfere with the magnetic circuit of the electromagnet. As illustrated, the armature member 64 carries a thin flexible ring diaphragm 68 having offset portions, the outer edge offset

portion being concave to the thin disk member 66 and having its outer edge disposed in seating engagement with the periphery of the thin disk 66. The diaphragm 68 is of non-magnetic material such as soft copper and has a thickness of the order of .005 of an inch.

In order to maintain the flexible diaphragm 68 in its seating engagement with the thin disk 66, a ring member 70 is disposed to seat within the body 44 with a flange 72 positioned against the outer edge of the flexible diaphragm 68 to maintain the outer edge of the flexible diaphragm 68 seated against the thin disk 66. The ring member 70 is preferably of stainless steel, being of a size that the inner edge of the ring terminates closely adjacent the flexible diaphragm 68, having an inner diameter for receiving the armature member 64. As illustrated, the ring member 70 is provided with a sloping or beveled surface 74, the purpose of which will be explained more fully hereinafter.

The spring member 76 is disposed to carry the armature member 64, the spring member preferably being a leaf spring of star shape or, as illustrated, comprising a circular disk with the ends or outer periphery bent to seat against the sloped surface 74 of the ring 70. As illustrated, disks or plates 78 and 80 of insulating material, such as fish paper, are disposed on the opposite faces of the spring member 76 to effectively insulate the spring member 76 from the armature member 64 and from a conducting plate 82 disposed adjacent the insulating plate 80. The assembly comprising the armature member 64, the flexible diaphragm 68, insulating washer 78, spring member 76, insulating washer or plate 80, and conducting plate 82 are maintained in assembled relation by means of the screws 84 and 86, it being noted that the screw 86 is maintained in an insulated relation with respect to the conducting plate 82 by an insulating washer 88. The conducting plate 82 carries a pusher member 90 disposed to seat against the pressure plate 16, whereby the spring member 76 applies pressure to the stack 12. The conducting plate 82 is also provided with a projection 92 to which a lead 94 may be connected, as illustrated in Fig. 1, the lead 94 extending through the dust cap 54.

With the leaf-spring member 76 assembled, as described hereinbefore, it is to be noted that the leaf spring applies pressure in the opposite directions to the ring member 70 and to the pressure plate 16, the pressure being sufficient to maintain the ring member 70 stationary and the outer edge of the flexible diaphragm 68 in seating engagement with the outer edge of the thin disk 66 of magnetizable material. Further, as the armature member is moved under the influence of the magnetic pull when the windings 48 are energized, the effective arm length of the spring member 76 changes since more and more of the spring 76 engages the sloped surface 74 of the ring member 70.

In operation, it is found that the regulator 10, as initially installed in a system (not shown), is relatively stable. However, after it has been in use for a period of time, it is found that the initial setting of the regulator is unsatisfactory for maintaining stability and that the armature member 64 tends to oscillate to a considerable degree as the energization of the winding 48 changes. Where the regulator embodies the thin disk 66 and the flexible diaphragm 68, as described hereinbefore, it is found that, when the windings 48 are energized, the thin disk 66 is magnetically held against movement by the magnetic pull of the electromagnet. Because the thin disk 66 quickly saturates, it will not interfere with the magnetic characteristics of the electromagnet.

With the thin disk 66 held in position as described, it is found that the outer edge of the flexible diaphragm 68 is so maintained in seating engagement with the outer edge of the thin disk 66 by the pressure of the spring 76 that, in effect, the thin disk 66 and the flexible diaphragm 68 cooperate to function in the manner similar to a bellows. Thus, as the energization of the winding 48 varies in response to a sudden change in load, the normal tendency of the armature member 64 to oscillate is damped for, as the flexible diaphragm 68 tends to flex, air is slowly forced out of the air space between the thin disk 66 and the flexible diaphragm 68 between the engaging edges of the members, or is slowly admitted to the air space, depending upon the direction that the armature member 64 tends to move.

In some cases, it is found that the seating engagement between the thin disk 66 of magnetizable material and the flexible diaphragm 68 of non-magnetic material is so tight that insufficient passage of air between the seating edges is obtained to permit the proper damping of the regulator. In this case, a small vent 96, illustrated in Fig. 2 of the drawing, is provided in the thin disk 66 for permitting a controlled flow of air to and from the air space between the cooperating disk 66 and diaphragm 68. As will be appreciated, the vent 96 may be disposed in the flexible diaphragm 68 instead of in the thin disk 66 and the size of the vent 96 will vary, depending upon the amount of damping required.

In addition to effectively damping the regulator, it is found that the flexible diaphragm 62 and the ring member 70 also cooperate to maintain the resistance of the stack of disks 14 at not less than a predetermined value. When the regulator is first assembled the disks 14 have a certain definite value but after the regulator is in use for a period of time the disks 14 become worn so that as pressure is applied to compress the stack 12 the resistance of the stack to the pressure of the spring 76 becomes less. Thus for the same pressure of the spring the electrical resistance of the stack 12 becomes less. If the air gap between the core member 40 and the armature member 64 is so large that the force of the spring 76 is larger than the magnetic pull, the spring tends to compress the stack 12 to thereby lower the electrical resistance of the stack. Such reduction in resistance in the regulator causes an overvoltage in the systems with which the regulators are employed.

By assembling the stack 12 to have a predetermined resistance and preloading the spring 76 with regard to the beveled surface 74 of the ring member 70 and the stack, it is found that when the disks 14 of the stack 12 are worn a predetermined amount, for example .010 inch, then as the force of the spring 76 becomes larger than the magnetic pull on the armature member 64, the armature carrying the flexible diaphragm is moved away from the core member under the influence of the spring 76 until the flexible diaphragm 68 engages the inner edge of the stationary ring member 70. It will be noted that, as clearly illustrated in Fig. 2, the engagement of the inner edge of the ring member 70, constituting a stop, with the flexible diaphragm 68 is along a line about the armature member 64

which line is at the most rigid part of the diaphragm adjacent the armature member as the force of the spring 76 tends to actuate the armature member 64 away from the core member 40. The engagement of the inner edge of the ring member 70 with the flexible diaphragm 68 prevents further movement of the armature member and pusher member 90 towards the stack 12 thereby preventing any further reduction in the electrical resistance of the stack 12 by compressing the disks 14.

With the regulator constructed in accordance with this invention, a very stable operation of the regulator is obtained for, as stated hereinbefore, even though the setting of the regulator is inaccurate, the damping action provided by the cooperating thin disk 66 and flexible diaphragm 68 is sufficient to damp excessive oscillations of the armature member 64 and consequently prevents large changes in the pressure applied to the stack 12. In addition to providing a stable operation for the regulator and preventing failure by reason of too great a reduction in resistance as the disks of the stack become worn, it is to be noted that advantage has been taken of the air gap between the core member and the armature member of the regulator so that the apparatus required for effecting damping constitutes a definite part of the regulator without increasing the size of the regulator or greatly increasing the weight thereof, it being appreciated that the members 66 and 68 are quite thin and have negligible weight as compared to the weight of the regulator.

I claim as my invention:

1. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, a spring member disposed to apply pressure to the stack through one of the pressure plates, an electromagnet having a core member and an armature member, the armature member being disposed to control the pressure applied to the stack in response to the energization of the electromagnet, a disk of magnetizable material disposed between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having a major part disposed in spaced relation to the disk of magnetizable material and having an outer edge disposed in seating engagement therewith, and means disposed to be held under pressure by the spring member against the outer edge of the flexible diaphragm to maintain the edge in its seating engagement whereby the disk of magnetizable material and the flexible diaphragm cooperate to effectively damp excessive movement of the armature member.

2. A regulator comprising, a combination, a stack of disks of resistance material, a pressure plate at each end of the stack, a spring member disposed to apply pressure to the stack through one of the pressure plates, an electromagnet having a core member and an armature member, the armature member being disposed to control the pressure applied to the stack in response to the energization of the electromagnet, a disk of magnetizable material disposed between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having a major

part disposed in spaced relation to the disk of magnetizable material and having an outer edge disposed in seating engagement therewith, means disposed to be held under pressure by the spring member against the outer edge of the flexible diaphragm to maintain the edge in its seating engagement whereby the disk of magnetizable material and the flexible diaphragm cooperate to effectively damp excessive movement of the armature member, and a vent disposed in one of the cooperating diaphragm and disk members to facilitate the ingress and egress of air to and from the space therebetween.

3. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, a spring member disposed to apply pressure to the stack through one of the pressure plates, an electromagnet having a core member and an armature member, the armature member being disposed to control the pressure applied to the stack in response to the energization of the electromagnet, a thin disk of magnetizable material disposed in the air gap between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having an outer edge portion concave wtih respect to the thin disk with the outer edge of said portion disposed in seating engagement with the thin disk, and means disposed to be held by the spring member against the outer edge of the flexible diaphragm to maintain the edge in its seating engagement, the thin disk and the flexible diaphragm cooperating to effectively damp excessive movement of the armature member.

4. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, a spring member disposed to apply pressure to the stack through one of the pressure plates, an electromagnet having a core member and an armature member, the armature member being disposed to control the pressure applied to the stack in response to the energization of the electromagnet, a thin disk of magnetizable material disposed in the air gap between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having a major part thereof disposed in spaced relation to the thin disk and having an outer edge disposed in seating engagement with the thin disk, and means disposed to maintain the outer edge in its seating engagement with the thin disk, said maintaining means being disposed to be held in position to apply pressure to the engaging surfaces by the spring member, the thin disk and the flexible diaphragm cooperating in their assembled relation to damp sudden movement of the armature member when the electromagnet is energized.

5. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, a spring member disposed to apply pressure to the stack through one of the pressure plates, an electromagnet having a core member and an armature member, the armature member being disposed to control the pressure applied to the stack in response to the energization of the electromagnet, a thin disk of magnetizable material disposed in the air gap between the core member and the armature mem-

ber to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having a major part thereof disposed in spaced relation to the thin disk and having an outer edge disposed in seating engagement with the thin disk, means disposed to maintain the outer edge in its seating engagement with the thin disk, said maintaining means being disposed to be held in position to apply pressure to the engaging surfaces by the spring member, the thin disk and the flexible diaphragm cooperating in their assembled relation to damp sudden movement of the armature member when the electromagnet is energized, and a vent disposed in one of the cooperating thin disk and diaphragm members to facilitate a controlled ingress and egress of air to and from the space therebetween.

6. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, an electromagnet having a core member and an armature member disposed to be energized, a disk of magnetizable material disposed between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having a major part thereof disposed in spaced relation to the disk of magnetizable material and having an outer edge disposed in seating engagement therewith, a ring member positionally disposed to seat against said engaging edge of the flexible diaphragm, and spring means carried by the armature member disposed to apply pressure in opposite directions to one of the pressure plates and the ring member and to support the armature member relative to the core member, the pressure applied to the ring member being sufficient to maintain the seating engagement between the flexible diaphragm and the disk of magnetizable material, the flexible diaphragm and disk of magnetizable material cooperating to damp excessive movement of the armature member.

7. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, an electromagnet having a core member and an armature member disposed to be energized, a disk of magnetizable material disposed between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having a major part thereof disposed in spaced relation to the disk of magnetizable material and having an outer edge disposed in seating engagement therewith, a ring member positionally disposed to seat against said engaging edge of the flexible diaphragm, spring means carried by the armature member disposed to apply pressure in opposite directions to one of the pressure plates and the ring member and to support the armature member relative to the core member, the pressure applied to the ring member being sufficient to maintain the seating engagement between the flexible diaphragm and the disk of magnetizable material, and a vent disposed in one of the flexible diaphragm and disk members to facilitate a controlled ingress and egress of air from the space therebetween whereby the members cooperate to damp excessive and sudden movements of the armature member.

8. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, an electromagnet having a core member and an armature member disposed to be energized, a thin disk of magnetizable material capable of being quickly saturated disposed between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having an outer edge portion disposed concave with respect to the thin disk but in seating engagement therewith, a ring member positionally disposed to seat against the flexible diaphragm in the region where the diaphragm seats against the thin disk, and a spring member carried by the armature member disposed to bias one of the pressure plates against the stack and the ring member against the flexible diaphragm while supporting the armature relative to the core member, the bias applied to the flexible diaphragm being sufficient to maintain the seating engagement between the flexible diaphragm and the thin disk whereby they cooperate to damp excessive movement of the armature member.

9. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, an electromagnet having a core member and an armature member disposed to be energized, a disk of magnetizable material disposed between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having a major part thereof disposed in spaced relation to the disk of magnetizable material and having an outer edge disposed in seating engagement therewith, a ring member positionally disposed to seat against said engaging edge of the flexible diaphragm, spring means carried by the armature member disposed to apply pressure in opposite directions to one of the pressure plates and the ring member and to support the armature member relative to the core member, the pressure applied to the ring member being sufficient to maintain the ring member stationary to insure the seating engagement between the flexible diaphragm and the disk of magnetizable material, the flexible diaphragm and disk of magnetizable material cooperating to damp excessive movement of the armature member, and means disposed to engage the flexible diaphragm upon a predetermined movement of the armature member away from the core member under the influence of the spring means to prevent the application of additional pressure to said one of the pressure plates and the stack of disks of resistance material.

10. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, an electromagnet having a core member and an armature member disposed to be energized, a disk of magnetizable material disposed between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the flexible diaphragm having a major part thereof disposed in spaced relation to the disk of magnetizable material and having an outer edge dis-

posed in seating engagement therewith, a ring member positionally disposed to seat against said engaging edge of the flexible diaphragm, spring means carried by the armature member disposed to apply pressure in opposite directions to one of the pressure plates and the ring member and to support the armature member relative to the core member, the pressure applied to the ring member being sufficient to maintain the ring member stationary to insure the seating engagement between the flexible diaphragm and the disk of magnetizable material, the flexible diaphragm and disk of magnetizable material cooperating to damp excessive movement of the armature member, and a stop carried by the stationary ring member disposed to project into the flexing path of movement of the flexible diaphragm to engage the diaphragm under predetermined operating conditions to prevent the application of additional pressure to said one of the pressure plates and the stack of disks of resistance material.

11. A regulator comprising, in combination, a stack of disks of resistance material, a pressure plate at each end of the stack, an electromagnet having a core member and an armature member disposed to be energized, a disk of magnetizable material disposed between the core member and the armature member to be magnetically held against movement when the electromagnet is energized, a flexible diaphragm of non-magnetic material carried by the armature member, the

flexible diaphragm having a major part thereof disposed in spaced relation to the disk of magnetizable material and having an outer edge disposed in seating engagement therewith, a ring member having a flange at an edge thereof disposed to seat against the flexible diaphragm in the region where the diaphragm seats against the thin disk, the ring member having an inner edge terminating closely adjacent the flexible diaphragm carried by the armature, and spring means carried by the armature member disposed to apply pressure in opposite directions to one of the pressure plates and the ring member and to support the armature member relative to the core member, the pressure applied to the ring member being sufficient to maintain the ring member stationary in the assembly to insure the seating engagement between the flexible diaphragm and disk of magnetizable material, the flexible diaphragm and disk of magnetizable material cooperating to damp excessive movement of the armature member, the inner edge of the stationary ring member being disposed to engage the flexible diaphragm upon a predetermined movement of the armature member away from the core member under the influence of the spring means to prevent the application of additional pressure to said one of the pressure plates and the stack of disks of resistance material, the resistance of the stack thereby being maintained at not lower than a predetermined value.

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