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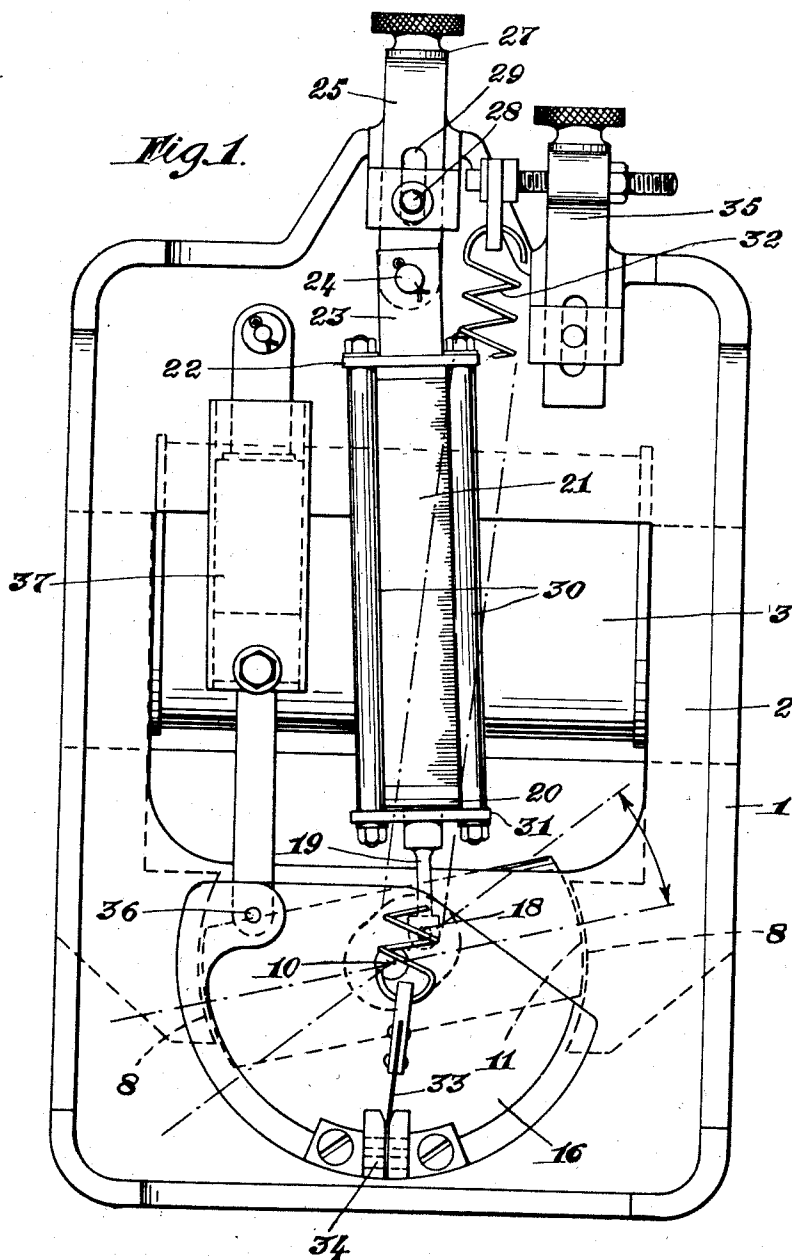
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ELECTROMAGNETIC REGULATING APPARATUS

Filed Aug. 3, 1933

4 Sheets-Sheet 1



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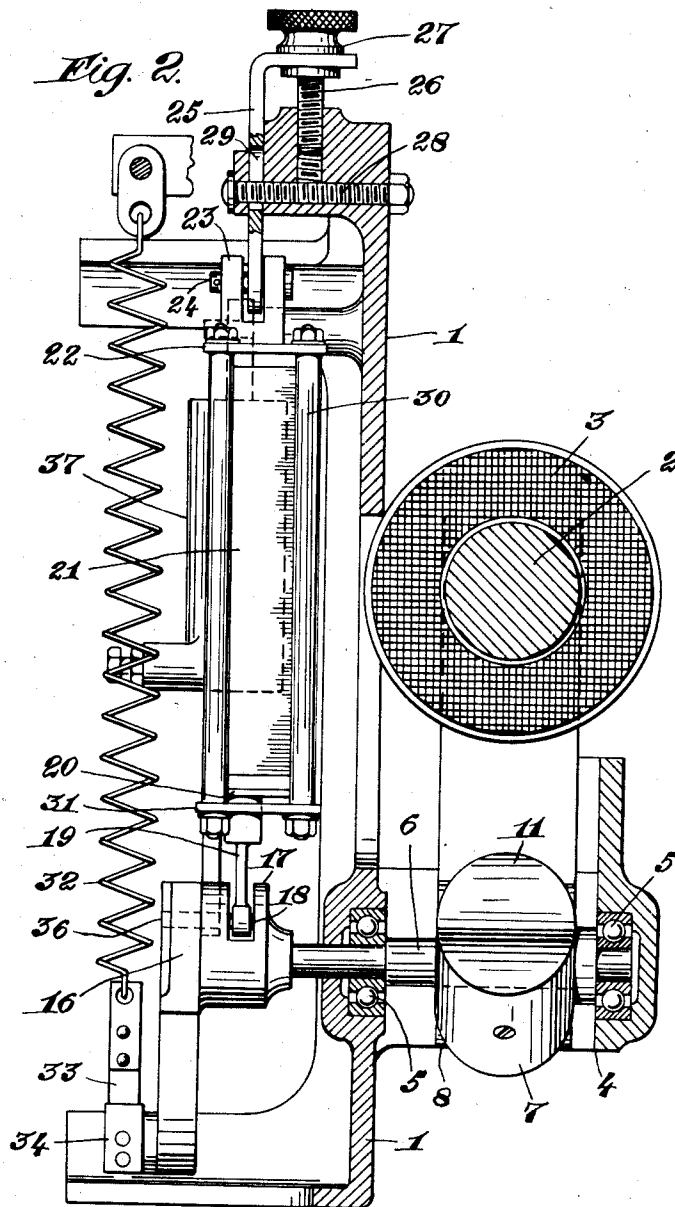
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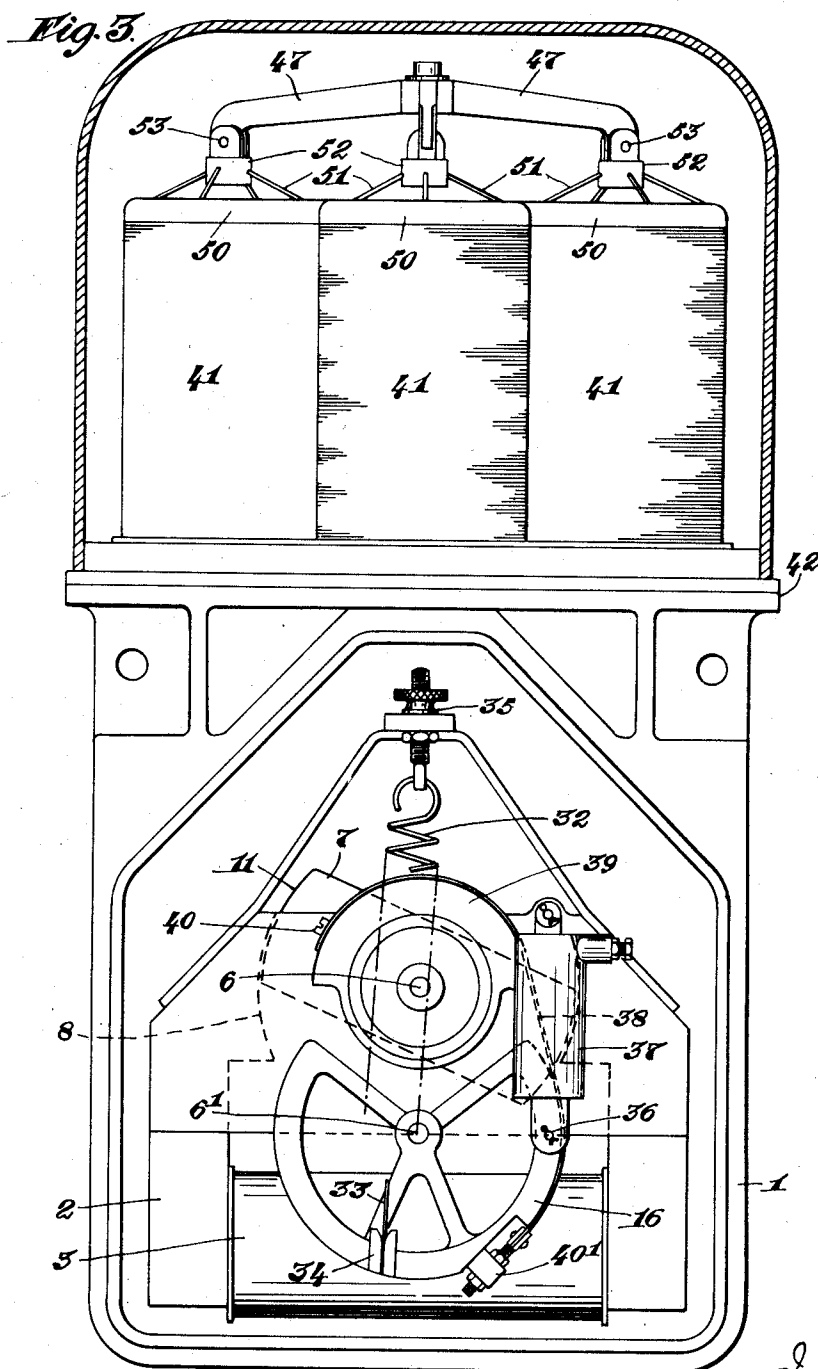
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4 Sheets-Sheet 3



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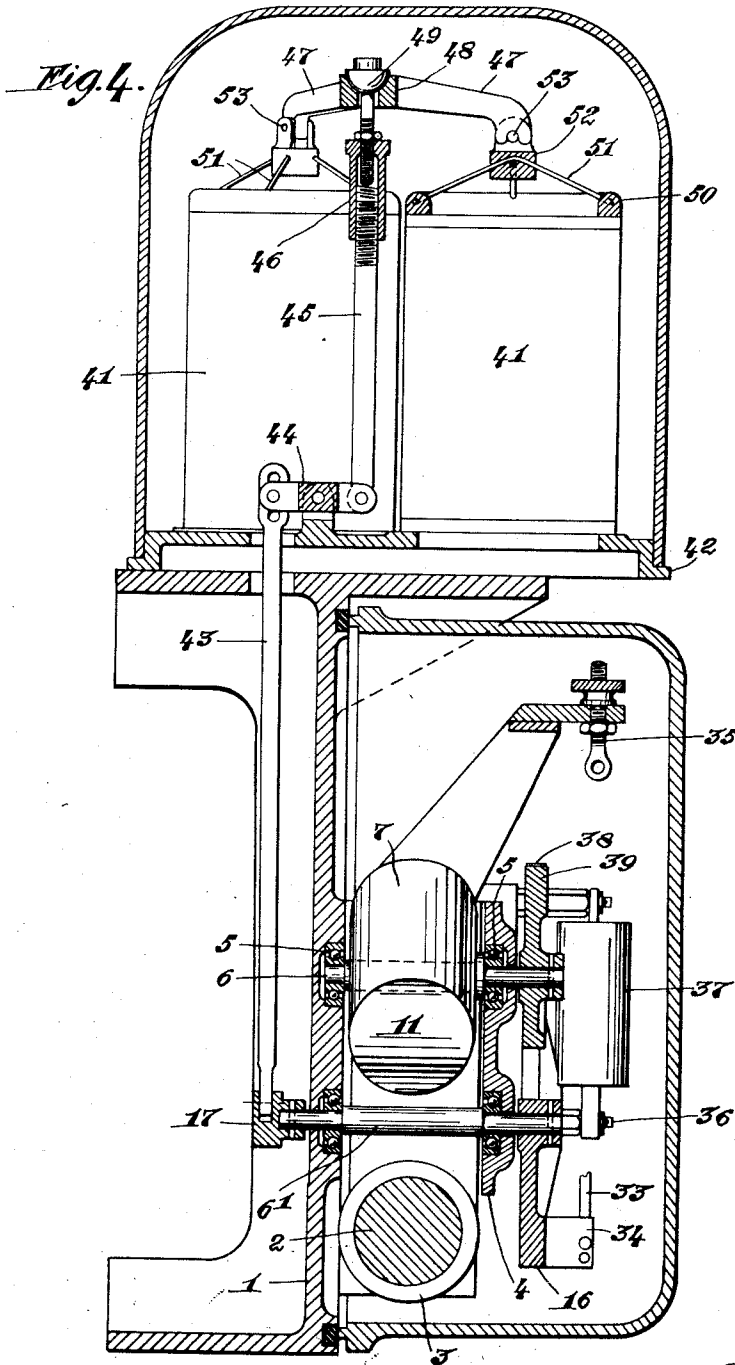
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ELECTROMAGNETIC REGULATING APPARATUS

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4 Sheets-Sheet 4



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UNITED STATES PATENT OFFICE

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ELECTROMAGNETIC REGULATING
APPARATUS

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8 Claims. (Cl. 171-229)

This invention concerns improvements in or relating to electro-magnetic regulating apparatus and is more especially concerned with so-called carbon pile regulators such as are commonly employed, for example, in lighting installations on railway vehicles.

In a regulator of this kind, it is necessary that the electro-magnetic actuating force, the reaction of the carbon pile, and the force of the usual spring or equivalent loading means should be balance over the range of operation of the regulator. As the reaction of the pile, which varies according to a given law, is a relatively small component, the required balance involves the matching of the torque movement characteristic of the electro-magnetic actuating device against that of the spring or other loading means. Thus, if the characteristic of the electro-magnetic device is of a complex or curved nature, as has hitherto been the case, a relatively complicated spring compensation system is required to provide a characteristic that can be matched with it.

The principal object of the present invention is to provide a magnet system having a characteristic of a shape substantially conforming to a part of a sine curve, particularly that part thereof which is nearly a straight line. Such a magnet system can be readily matched with a relatively simple spring system. With this object in view according to the present invention use is made of a magnet system with a rocking rotor whereof the faces which come opposite the pole-faces of the magnet in the attracted position of said rotor are of circular shape.

Thus the magnet system may comprise a rotor wholly or in part of substantially circular cross-section mounted so as to be capable of rocking about a diametrical axis at the mid-point of its length and a magnet having opposed pole-faces between which the rotor is arranged to rock, said faces being of a concave cylindrical profile concentric with the aforesaid axis of the rotor and the rotor-ends being of convex cylindrical profile also concentric with said axis. The said pole-faces are preferably of rectangular shape. A magnet system of this nature has a declining characteristic of the aforesaid required shape over a large range of movement of the rotor, i. e. from an initial position in which the leading tips of the rotor almost overlap, or slightly overlap, the adjacent tips of the pole-faces to a final position in which the rotor is located between the pole-faces. As a consequence, the magnet system can be readily matched with a spring system

consisting essentially of a simple spring acting upon the rotor through a plain crank arranged so that the lever arm decreases as the rotor is attracted into the magnet.

Two embodiments of the invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a rear elevation of a carbon pile regulator intended more especially for dynamo regulation purposes in train lighting installations,

Fig. 2 is a vertical section thereof.

Fig. 3 is a front elevation of a carbon pile regulator intended more especially for lamp voltage regulation purposes in train lighting installations, and

Fig. 4 is a vertical section thereof.

Referring first of all to Figs. 1 and 2, the various component parts of the regulator are mounted upon a frame 1. The iron magnet core 2, which is of approximately inverted U-shape and carries the exciting winding or windings 3 upon its yoke portion, is carried in a forward extension 4 of the frame 1. Supported in ball bearings 5 in the main frame 1 and forward extension 4 is a spindle 6 carrying an iron rotor 7 located between the opposed pole-faces 8 of the magnet core. These pole-faces are of a concave substantially cylindrical profile (Fig. 1) concentric with the axis 10 of rotation of the rotor and of rectangular shape, as shown in Fig. 2. The convex end-faces 11 of the rotor are also of cylindrical profile struck from the axis 10. Consequently, when the rotor 7 is in the attracted position (Fig. 1) in which it extends between the pole-faces 8, the air gaps between said pole-faces and said rotor end-faces are of uniform width. The rotor 7 is a cylindrical body of uniform circular shape. With this arrangement it is possible to provide a magnet system having a declining characteristic of a shape substantially conforming to a part of a sine curve, particularly that part thereof which is nearly a straight line.

An overhanging extension of the spindle 6 on the rear side of the frame 1 carries a disc 16 and a crank 17. The latter is connected by a crank-pin 18 to a push rod 19 carrying a compression plate 20. The pile 21 of thin carbon discs is arranged between the plate 20 and a top plate 22 having an upward extension 23 which is connected by a pivot 24 to a bracket 25. This bracket is mounted upon the top of the frame 1 in a vertically adjustable manner by means of a screw 26 with a grooved head 27 engaged by the forked end of said bracket and is locked in position by

means of a screw 28 passing through a slot 29 in said bracket. Insulated pins 30, dependent from the plate 22 and carrying a plate 31 through a hole in which the rod 19 freely passes, constitute a cage in which the pile guided with a slight degree of freedom. A practically vertically disposed helical tension spring 32 of substantial length is connected between a metal tape 33, which is anchored to the disc 16 between slightly curved blocks 34 preventing too sharp flexure of the tape 33, and an adjustable attachment means 35 which is substantially identical with that of 25—27 for the pile. The disc 16, which may be mutilated as shown, also carries a crank-pin 36 connected with a dash-pot 37.

The point of attachment of the tape 33 to the disc 16 is somewhat to one side of the bottom dead centre thereof. As the rotor 7 moves between the pole faces 3 from its initial position, in which its longitudinal axis lies as indicated by a chain line in Fig. 1, towards the end position illustrated in Fig. 1, the aforesaid point of attachment travels towards the dead centre so that the effective lever arm with which the spring 32 acts upon the rotor decreases. In the range of operation of said rotor, however, said point never reaches the dead centre. It will be appreciated that the characteristic of this spring system is determined practically wholly by the variation of the lever arm with which the spring acts, said spring itself suffering only a relatively small elongation and contraction. Since, however, the lever arm variation, which is governed by a sine curve law, corresponds to that short length of the sine curve which is practically a straight line, it follows that the spring system has a declining characteristic which can be readily matched with that of the magnet system. The adjustable attachment means 25—27 and 35 permit of adjustment of the initial compression and tension respectively in the carbon pile and spring. The manner of operation of such a regulator is well known and need be only briefly referred to: With increasing excitation of the magnet winding or windings 3, connected for example across the dynamo to be regulated, the rotor 7 tends to be attracted from its initial position (see the position of the axis as indicated by a chain line in Figure 1) towards the final position illustrated in Figure 1, this movement being resisted by the spring 32. The said rotor movement, translated through the push rod 19 and plate 23 results in the decompression of the carbon pile 21. The resultant increase of the resistance is utilized for regulation purposes by, for instance, disposing the carbon pile in series with the field windings of the dynamo to be regulated. The dash pot 37 counteracts any tendency towards jerking or hunting action of the regulator.

As regards the magnet system, the lamp voltage regulator illustrated in Figures 3 and 4 is essentially similar to that previously described. The disposition of the spring and the carbon piles and the means for their control are, however, somewhat different. The disc 16 and crank 17 are not mounted directly upon the rotor spindle 5 but upon a separate spindle 6¹ disposed vertically below it. The two spindles 6 and 6¹ are geared together by a flexible metal tape 38 which is wrapped over arcs of the rims of the disc 16 and a disc 39 on the spindle 6 (Fig. 3). The tape is anchored to the disc 39 at 40 and to the disc 16 by an adjustable anchorage 40¹. The diameter of the disc 16 is larger than that of the disc 39 so that the angular movement imparted to the for-

mer by the latter is smaller than the angular movement of the rotor 7 but is proportional thereto. With such an interposed gearing, the range of angular movement of the rotor is not unduly restricted, even if it is desired to keep the angular movement of the spring anchorage 34 within a range corresponding to the straight line portion of the sine curve.

The three carbon piles 41 provided to carry the lamp current are mounted above the magnet system upon a separate platform 42 secured to the frame 1. In place of the push rod 19 of Figures 1 and 2, use is made of a push rod 43 connected by a see-saw lever 44 to a pull-rod 45 around which the piles 41 are grouped. This pull-rod 45 incorporates a length-adjustment device which takes the form of a turnbuckle 46 but is designed to give a finer adjustment than an ordinary turnbuckle. The turnbuckle 46 has at the two ends threads of the same sense but of somewhat different pitch. Such a device provides a very fine adjustment as the effect of the two threads is differential, i. e. for one turn of the device, the length adjustment is equivalent only to the difference between the pitches of the two threads. The pull rod 45 acts upon the carbon piles 41 through an equalizing spider 47 having a part spherical socket 48 engaged by a part spherical head 49 on the rod 45.

The carbon piles 41, when in use, experience a considerable rise of temperature with attendant expansion which, unless compensated for, may seriously derange the precision of the regulator. According to a further feature of the invention, a compensating device for this purpose comprises a ring 50 of a material which expands with rise of temperature, a number of spokes 51 of a material with a relatively low or negligible thermal expansion, such as mild steel or nickel-steel alloy, and a hub 52, the spokes being arranged at an angle of inclination to the plane of the ring. This device is shown interposed between each carbon pile and the equalizing spider 47. The ring 50 which is of a material, for example aluminium, of good conductivity and not too large heat capacity so as to respond readily to temperature changes in the pile, is mounted upon the pile with the interposition of the usual metal contact piece and an insulating disc or washer. The hub 52 is connected pivotally with the spider 47, said hub being extended upwardly and the extension divided by a diametrical slot, whilst holes for a pivot pin 53 are drilled at right angles to the slot. The effect of this compensating device is as follows: The ring 50 will follow the temperature rise of the carbon pile 41 and will expand in diameter. The spokes 51 on the other hand, will expand little or not at all so that their inclination will decrease, causing a decrease in the depth of the device between the hub 52 and ring 50. The size of the ring and initial inclination of the spokes is designed so that the decrease in depth of the compensating device substantially counterbalances the increase in length of the carbon pile itself over a sufficient range of temperature variation. In order to permit of the variation of the inclination of the spokes 51, these may be made of relatively flexible wire, a sufficient number of spokes being provided to take the maximum pressure exerted on the pile.

The manner of operation of such a lamp voltage regulator is well known and requires no detailed description here. The most usual arrangement is that the magnet winding 3 is subject to the lamp voltage whilst the carbon piles 41 con-

stitute a resistance in series with the lamp load. The separate piles are connected in parallel with each other. Upon the lamp voltage tending to rise, the regulator acts to relieve the pressure upon the piles and thus to increase their resistance and so maintain the voltage upon the lamps themselves constant. The initial setting of the regulator is effected by the adjustment means 35, 40¹ and 46.

I claim:—

1. In electro-magnetic regulating apparatus, particularly a carbon pile regulator for use in train lighting installations, the combination of a magnet system comprising a magnet with pole faces, and a rotor mounted so as to be capable of rocking in relation to the pole end-faces, the faces of the rotor which come opposite to said pole faces in the attracted position of said rotor being of substantially circular shape when viewed endwise and a spring system connected to the said rotor and adapted for exerting thereon a torque which opposes the magnet attraction and varies inversely with the rotor movement in an approximately rectilinear relationship.

2. In electro-magnetic regulating apparatus, particularly a carbon pile regulator for use in train lighting installations, the combination of a magnet system comprising a magnet with diametrically opposed pole-faces, and a rotor of substantially circular cross-section mounted so as to be capable of rocking about a diametrical axis at the mid-point of its length and between the opposed pole faces, said pole faces being of a concave cylindrical profile concentric with said axis and the rotor ends of convex cylindrical profile concentric with said axis and a spring system connected to the said rotor and adapted for exerting thereon a torque which opposes the magnet attraction and varies inversely with the rotor movement in an approximately rectilinear relationship.

3. In electro-magnetic regulating apparatus, particularly a carbon pile regulator for use in train lighting installations, the combination of a magnet system comprising a magnet with pole faces of rectangular shape, and a rotor mounted so as to be capable of rocking in relation to the pole faces, the end-faces of the rotor which come opposite to said pole faces in the attracted position of said rotor being of substantially circular shape when viewed endwise and a spring system connected to the said rotor and adapted for exerting thereon a torque which opposes the magnet attraction and varies inversely with the rotor movement in an approximately rectilinear relationship.

4. Electro-magnetic carbon pile regulator, comprising a magnet system with a rotor of substantially cylindrical shape rockable about an axis perpendicular to the cylinder axis, a carbon pile operatively connected to said rotor, a tension spring extended at a substantially constant

tension, and a simple crank member operatively connected to said rotor, the tension spring being connected to said crank member at a point in the vicinity of its dead centre position, which point, upon the rocking of the rotor in the direction of attraction, moves towards the dead centre position.

5. Electromagnetic carbon pile regulator, comprising a magnet system with a rotor of substantially cylindrical shape rockable about an axis perpendicular to the cylinder axis, a carbon pile operatively connected to said rotor, a tension spring exerting a substantially constant tension, a crank member to which said spring is attached at a point in the vicinity of its dead centre position, reduction gearing between the rotor and crank member such that the latter performs a movement proportional to but smaller than that of the former, the aforesaid point of attachment being so located that, upon the rocking of the rotor in the direction of attraction, it moves towards the dead centre position.

6. Regulating device for a train-lighting installation comprising an electro-magnet of substantially U-shape with pole pieces facing each other, a rotor of cylindrical shape mounted to rock about a diametrical axis between said pole pieces, a spring exerting a substantially constant tension, a carbon pile operatively connected to said rotor for control thereby and a simple crank member connected to said rotor and having the spring attached to it, said crank member being arranged so that it moves towards its dead centre position upon attraction of said rotor by said magnet.

7. In a carbon pile regulator, a pile assembly comprising a carbon pile, an abutment for said pile, pile-compressing means, and temperature compensation means consisting of a hub, a ring of material which expands with rise of temperature and a number of spokes which are made of a material with a relatively low thermal expansion and are connected, at an angle to the plane of the ring, between the latter and the hub, said ring and hub being interposed between and in abutting relationship with adjacent parts of the pile assembly.

8. In a carbon pile regulator, a magnet system comprising a magnet having pole faces, and a rotor mounted so as to be capable of rocking in relation to the pole faces, the end faces of the rotor which come opposite to said pole faces in the attracted position of said rotor being of substantially circular shape when viewed endwise, and a spring system connected to said rotor and capable of exerting thereon a torque in opposition to the magnet attraction, the said spring system torque varying in a relationship which follows that part of a sine curve which approximates a straight line.

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