

April 10, 1945.

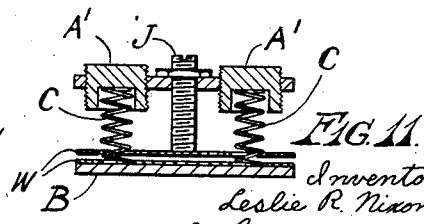
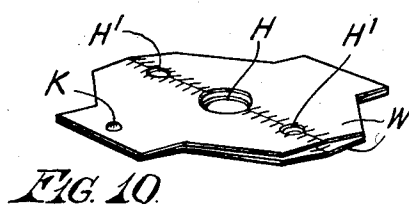
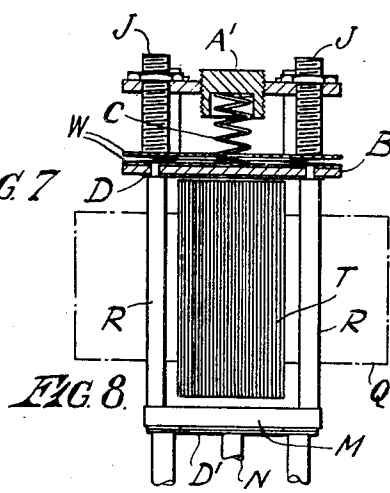
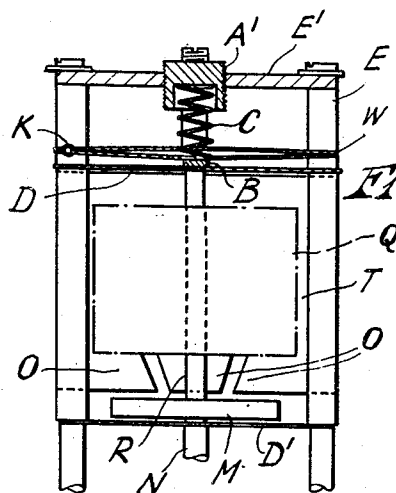
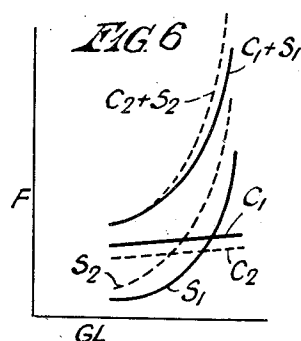
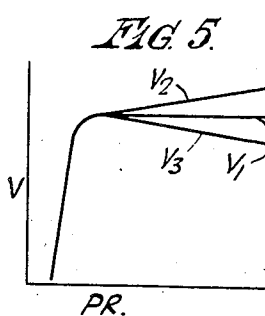
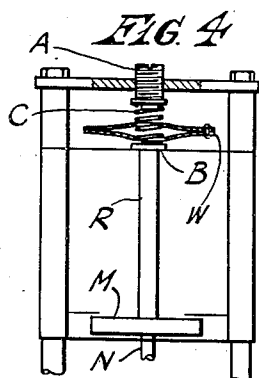
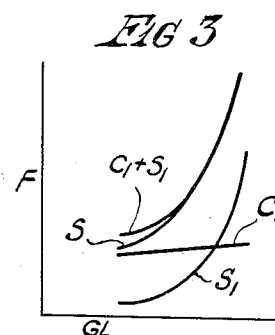
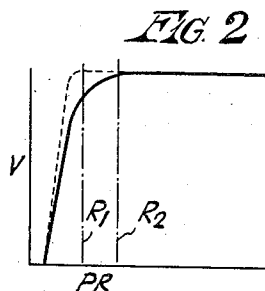
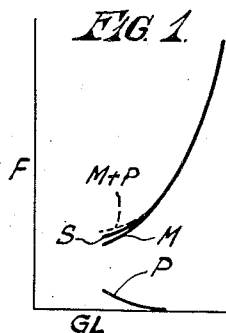
L. R. NIXON

2,373,591

ELECTRIC REGULATOR OF THE CARBON PILE TYPE

Filed May 16, 1942

2 Sheets-Sheet 1



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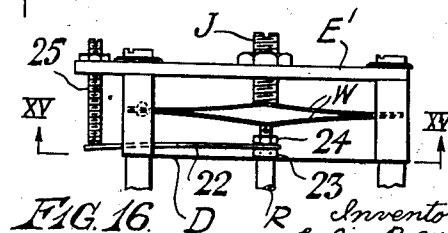
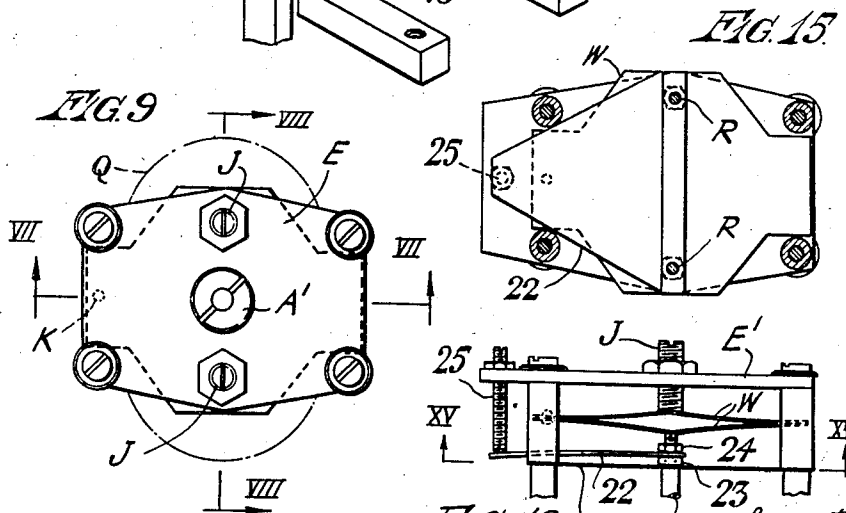
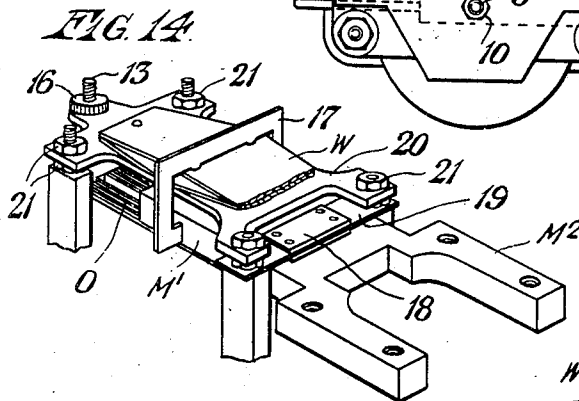
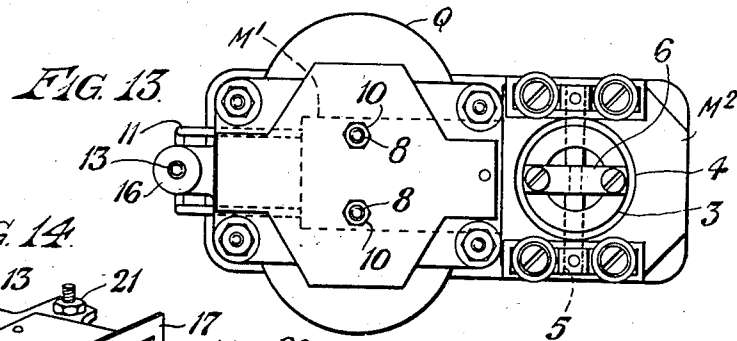
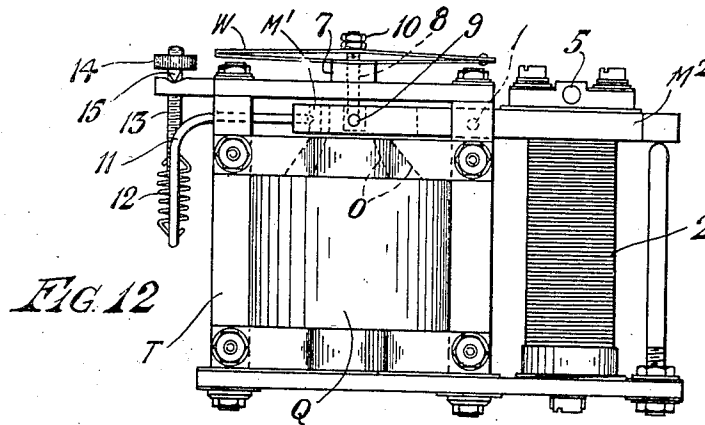
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ELECTRIC REGULATOR OF THE CARBON PILE TYPE

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,373,591

ELECTRIC REGULATOR OF THE CARBON
PILE TYPE

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Application May 16, 1942, Serial No. 443,315
In Great Britain August 29, 1941

6 Claims. (Cl. 201—51)

This invention comprises improvements in and connected with electric regulators of the carbon pile type.

Spring systems for such regulators have been proposed, having a spring rate which increases progressively as the clapper armature or core is attracted by the magnet. These spring systems have comprised two springs, in series, such springs co-operating during flexure mutually to shorten their effective lengths and thereby to increase their combined stiffness. For example, a spring system has comprised two bowed blade springs with their concave surfaces towards one another, one blade resting against an abutment and the other blade being engaged by means such as a rod extending from the magnet armature. Under initial loading for the maximum compression of the pile, the ends parts of the blades are flattened somewhat against one another. When the magnet is energized and attracts its armature, the latter compresses the spring arrangement to the relief of the pile, whereby the end parts of the spring blades flatten against one another to an increasing extent, leaving only the middle portions oppositely bowed. The effect of this is that during magnetic attraction of the armature and the consequent shortening of the air gap, the spring arrangement acquires a progressive stiffness.

A spring system such as that described in the preceding paragraph and which may be said to comprise a double-V spring arrangement, can be shown to have the following law:

$$y = \frac{k}{\sqrt{w}}$$

where

y = the distance or gap between the spring blades at the apices.

k = a constant, and

w = the force applied.

A spring system of this order may give characteristics having the disadvantage that they result in a voltage lacking a desirably high degree of accuracy and even in instability of the regulator. The object of the present improvements is to remove this disadvantage and to provide a spring system adapted for giving very accurate regulation and complete stability.

According to the present invention, a spring arrangement of variable rate is combined with a secondary spring of substantially constant low rate, which is arranged to operate in parallel with the spring arrangement aforesaid, and by this combination, adjustment of the slope of a char-

acteristic can be very conveniently controlled by merely varying the initial loading forces to which the component springs are set by abutment screws.

5 According to one form of the invention a spring system is advantageously used which comprises in combination a plate spring or blade spring arrangement adapted for having a spring rate which increases progressively as the clapper
10 armature or core is attracted by the magnet, and an auxiliary spring of substantially constant low rate in parallel with the plate spring or blade spring arrangement aforesaid.

In order to enable the invention to be readily understood reference is made to the accompanying drawings wherein:

Figure 1 is a diagram showing the inherent characteristic of a double-V spring arrangement and magnet and pile characteristics.

20 Figure 2 is a diagram showing voltage regulating characteristics.

Figure 3 is a diagram showing the spring characteristic seen in Figure 1 and modified characteristics.

25 Figure 4 is a diagrammatic sectional elevation of a combination spring system in accordance with the present improvements.

Figure 5 is a diagram showing different voltage regulating characteristics, and

30 Figure 6 is a diagram similar to Figure 3 but showing other characteristics obtained by means of adjustable spring abutments.

Figure 7 is a sectional elevation illustrating a spring system similar to that illustrated in Figure 4 as applied to an electric regulator, the section being taken on the line VII—VII of Figure 9.

Figure 8 is a view similar to Figure 7 but with the section taken on the line VIII—VIII of Figure 9.

40 Figure 9 is a top plan view of Figure 7.

Figure 10 is a perspective view illustrating the bowed spring plates removed from the regulator seen in Figures 7 to 9.

45 Figure 11 is a fragmentary sectional elevation illustrating a modification of the spring system seen in Figure 8.

Figure 12 is a side elevation of another construction of carbon pile regulator embodying a spring system in accordance with the present improvements.

50 Figure 13 is a plan of Figure 12, and

Figure 14 is a perspective view illustrating a modification of the regulator seen in Figures 12 and 13.

55 Figure 15 is an inverted sectional plan and Fig-

ure 16 is an elevation illustrating a spring system comprising the combination of bowed spring plates and a blade spring, the section for Figure 15 being taken on the line XV—XV of Figure 16.

Referring to Figure 1, wherein force is plotted vertically, as indicated by F, and gap length is plotted horizontally, as indicated by GL, the curve marked S is the spring characteristic and is very similar in form to the curve marked M which is the magnet characteristic with constant excitation. The curve marked P is the carbon pile characteristic. The dotted curve marked $M+P$ is the combined characteristic of magnet and pile. Now, the ideal spring characteristic is one which corresponds with the dotted curve $M+P$ and not with the curve S, for the spring force should at all points equal the sum of the magnet and pile forces.

In Figure 2 voltage is plotted vertically, as indicated by V, and pile resistance is plotted horizontally, as indicated by $P-R$. The full-line curve is the characteristic of a simple spring system having a characteristic such as that marked S in Figure 1. The dotted-line curve, however, is the regulating characteristic which would be obtained with an ideal spring system having the characteristic shown by the dotted curve in Figure 1. With the ideal spring system it will be seen that the lower limit of the effective range of carbon pile resistance has been reduced from R_2 to R_1 .

In Figure 3, the simple spring curve S of Figure 1 has been reproduced for convenience. Figure 3 also shows a characteristic S_1 which may be obtained with a similar simple spring system but with different design proportions such as those giving a smaller initial slope to the sides of the V's. In addition, Figure 3 shows the characteristic C_1 of a low rate spring. The combination of the two characteristics C_1 and S_1 results in a characteristic C_1+S_1 which is a close approximation to the ideal characteristic $M+P$ in Figure 1.

Figure 4 illustrates one combination of springs in accordance with the present improvements. This combination comprises a so-called double-V spring W and a low rate coil spring C and these springs press against a bridge piece B which is in contact with rods R attached to an armature M. The outer end of the coil spring C rests against an abutment screw A which is adjustable in the framing of the regulator and the spring C passes through a hole in the double-V spring so as to be able to press freely with its inner end against the bridge piece B. The double-V spring consists of two oppositely bowed blades or plates which may be connected together at one end by a rivet, as shown, the inner blade bearing against the bridge piece B and the outer blade resting against abutment screws one on either side of the screw A and therefore not seen in Figure 4. The several abutment screws serve for the initial loading of the springs for maximum compression of the pile (not shown) to which pressure is transmitted by way of the rods R, armature M and rod N.

A combination of springs such as hereinbefore described presents the advantage of a very convenient and useful adjustment of the slope of the regulating characteristic.

With a simple double-V spring, and if this has been designed to give a slightly different characteristic from that required by the magnet, the voltage regulating characteristic may be either drooping or rising as compared with the

ideal. For example, in Figure 5, V_1 is the ideal characteristic, whereas V_2 rises in consequence of too steep a spring rate being used and V_3 falls in consequence of the spring rate being too low. The characteristics V_2 and V_3 have the disadvantage that they result in less accurate voltage regulation and the drooping characteristic V_3 has the further disadvantage that it is likely to cause instability of the regulator. The steepness of the characteristic of a double-V spring can be controlled by adjustment of the angle contained by the V's or by other dimensional adjustments, none of which is a convenient method to apply on test. With a combination of springs as provided by the present improvements adjustment of the slope of the characteristic can be very conveniently controlled by varying the initial loading forces to which the springs are adjusted by means of their abutment screws.

In Figure 6, the characteristics S_1 , C_1 and C_1+S_1 of Figure 3 are reproduced. If the abutment screw or screws of the double-V spring is or are tightened the dotted characteristics S_2 can be obtained. This, combined with a lower force from the coil spring, as represented by the dotted curve C_2 gives an addition shown by the dotted curve C_2+S_2 . By this means it will be seen that the general slope of the combined spring characteristic has been increased.

Figures 7 to 10 illustrate a construction very similar to that seen in Figure 4 but in greater detail. In this construction the armature M is seen to be connected by a pair of rods R with a bridge piece B. The bridge piece is connected with a thin flexible plate or diaphragm D supported on the framing E and serving for the guidance of the rods R and armature M. The abutment screw A^1 for varying the compression of the coil spring C is in this example cupped to receive one end of such spring. The other end of the spring C passes through holes H (seen clearly in Figure 10) formed in the spring plates W and presses against the bridge piece B. The screw A^1 screws through a hole in the back plate E^1 of the framing E and on each side thereof are screws J which also screw through the back plate E^1 and engage one of the plates of the spring W for varying the compression of such spring and its loading on the bridge piece B. The spring plates W may be connected together at one end by a rivet K and may be formed with small holes H^1 , Figure 10, for engagement with pins or projections on the ends of the screws J, such engagement being effective for retaining the spring plates W in their proper position. The armature M has connected to its underside a rod N for transmitting pressure to a carbon pile (not shown). The rod N and armature M are connected also with a thin flexible plate or diaphragm D^1 which is supported on the framing E and co-operates with the diaphragm D in the guidance of the rods R and the maintenance of the armature M parallel with the poles O of the electro-magnet. Q indicates the coil of the electro-magnet and T indicates a laminated magnet structure providing the poles O aforesaid. It will be apparent that when the coil Q is energized the armature M is attracted towards the poles O, thereby relieving pressure of the rod N upon the pile and further compressing the spring system. In such further compression, the spring plates W wrap against one another in their end portions and leave only the middle portions bowed towards one another. Thus, the

spring action of the plates W acquires considerably increased stiffness and resistance under such further compression, whereas the resistance of the coil spring C increases almost imperceptibly under such further compression, these conditions being in accordance with what has already been explained by the aid of the diaphragm. By adjusting the screw A¹ or the screws J, or both A¹ and J, the initial loading of the springs can be altered to suit the various requirements hereinbefore explained.

According to the modification illustrated in Figure 11, the initial compression of the spring plates W is adjusted by a single adjustment screw J which is disposed in the middle. In this case, two coil springs C are used disposed one at each side of the screw J and each of the springs C is engaged with an adjustable screw A¹ by means of which its initial compression can be altered.

In the further modification illustrated in Figures 12 and 13, T again indicates a laminated magnet structure providing poles O and adapted for being energized by a coil Q. In this case, however, a pivoted armature M¹ is employed, the pivot I being disposed between the armature M¹ and an extension M² thereof. The carbon pile 2 rests upon a frame member of the regulator and is pressed upon by the extension M² through the medium of a ring 3. The latter is disposed in a hole 4 (Figure 13) formed in the extension M² and is pivotally supported on a fixedly mounted pin 5. A blade spring 6 diametrically fixed on the ring frictionally engages a reduced middle portion of the pin 5 so that pivotal movement of the ring 3 about the pin 5 is stiff. Thus, in spite of tilting movements of the extension M² the ring 3 always initially applies pressure squarely and evenly to the pile 2. A spring W, consisting of two oppositely bowed spring plates similar to those hereinbefore described, rests with its lower blade upon a block 7 on the framing, this block and the spring plates being perforated for the passage of rods 8 which are pivotally connected with the armature at 9. The outer ends of the rods 8 are screw threaded to receive nuts 10, the adjustment of these nuts 10 being effective for altering the initial compression of the spring W. A rod 11 is bent to a U form and the limbs of the U are then bent to provide horizontal and vertical portions. The ends of the horizontal portions are fixed in the armature M¹, the loop at the bottom of the vertical portions which are outside of the framing, serving as an anchorage for the lower end of a coil spring 12. The upper end of the spring 12 is hooked to the lower end of a screw 13 which extends upwards through a hole in a lug on the framing and through the nut 14 having knife edge projections 15 for bearing in notches in the said lug, as will be apparent from Figure 12. This nut 14 screwing on the screw 13 serves for adjusting the initial tension of the spring 12. The spring W acting against the nuts 10 exerts an upward pull on the rod 8 and consequently upon the armature M¹. This tends to depress the armature extension M² and to compress the pile 2 through the medium of the ring 3. The action of the spring W is assisted by the upward pull of the coil spring 12 on the bent rod 11 fixed to the armature M¹. The combined action of the springs W and 12 is opposed by the armature M¹ when the coil Q is energized, increasing energization of the magnet having the effect of increasing the compression of the spring W and relieving the compression exerted on the pile 2 by the springs. With increasing compression

of the spring W, the end portions of the plates thereof increasingly flatten against one another and thereby increase the stiffness of the spring W as and for the purpose already explained, whereas the action due to the coil spring 12 is only slightly changed during armature movements.

Figure 14 illustrates a construction somewhat similar to that illustrated in Figures 12 and 13. In Figure 14, however, the double plate spring W is engaged by the top bar of a metal loop or frame 17 having its bottom bar engaged with the armature M¹. The latter is not supported by a pivot pin but is attached by a clamping plate 18 to a flexible strip 19, pivotal movements of the armature M¹ being permitted by the flexing of the strip 19. The extension M² of the armature in this case is forked for enabling the presser ring 3 of Figures 12 and 13 to be mounted between the prongs of the fork. The spring W rests with its lower bowed plate upon a frame plate 20 which can be adjusted up or down by means of nuts 21 in order to vary the initial compression of the spring W. 16 indicates a nut for adjusting a screw 12 which has attached to it a coil spring in the same manner as the screw 13 has attached to it the coil spring 12 in Figure 12. In this construction, attraction of the armature M¹ towards the magnet poles O is opposed by the spring W acting against the top bar of the frame 17 attached to the armature M¹. In other respects, the operation is the same as that described with reference to Figures 12 and 13.

According to the further modification illustrated in Figures 15 and 16, the auxiliary spring takes the form of a blade spring 22 instead of a coil spring such as that marked C or 12 in the preceding figures. In this modification, the ends of the armature rods R which pass through the diaphragm D are reduced and screw threaded to receive nuts 23 and 24. The nuts 23 securely connect the rods R with the diaphragm D and the nuts 24 securely connect the wide end or base of the blade spring 22 with the rods R, the blade spring 22, as will be apparent from Figure 15, being of a somewhat triangular shape as seen in plan. The apex or narrow end of the blade spring 22 is engaged by a screw 25 which can be adjusted in the back plate E¹ of the frame for increasing or decreasing the flexure of the blade spring 22. The lower bowed plate of the spring device W is engaged by the extremities of the armature rods R and the upper plate presses against an adjustable screw or screws J. The loading due to the spring W can be varied by adjusting the screw or screws J and the loading due to the spring 22 can be varied by adjusting the screw 25. When the armature is attracted the spring W is compressed and increases in stiffness as already explained. The blade spring 22, however, merely flexes and the action due thereto changes only slightly during armature movements.

I claim:

1. In an electric regulator of the carbon pile type, the combination of a resistance pile, presser means engaged with one end of said pile, a rigid abutment, a variable rate spring operative between said abutment and said presser means for compressing said pile, a substantially constant low rate spring operative between said abutment and said presser means and in parallel with said variable rate spring, and an electro-magnet operative upon said presser means in opposition to said springs.

2. In an electric regulator of the carbon pile

type, the combination of a resistance pile, presser means engaged with one end of said pile, a rigid abutment, a main spring operative between said abutment and said presser means for compressing said pile, said main spring being of the kind which progressively increases its stiffness under compression, a substantially invariable low rate spring operative between said abutment and said presser means and in parallel with said main spring, and an electro-magnet operative upon said presser means in opposition to said springs.

3. In an electric regulator of the carbon pile type, the combination of a resistance pile, presser means engaged with one end of said pile, a rigid abutment, a main spring operative between said abutment and said presser means for compressing said pile, said main spring comprising two oppositely bowed plates adapted to flatten against one another under compression and thereby to progressively increase the stiffness of such main spring, a substantially constant low rate spring operative between said abutment and said presser means and in parallel with said main spring, and an electro-magnet operative upon said presser means in opposition to said springs.

4. In an electric regulator of the carbon pile type, the combination of a resistance pile, presser means engaged with one end of said pile, a rigid abutment, a variable rate spring operative between said abutment and said presser means for compressing said pile, a spring adjustment operable for varying the compression loading on said pile due to said variable rate spring, a substantially constant low rate spring operative be-

tween said abutment and said presser means and in parallel with said variable rate spring, and an electro-magnet operative upon said presser means in opposition to said springs.

5. In an electric regulator of the carbon pile type, the combination of a resistance pile, presser means engaged with one end of said pile, a rigid abutment, a variable rate spring operative between said abutment and said presser means for compressing said pile, a spring adjustment operable for varying the compression loading on said pile due to said variable rate spring, a substantially constant low rate spring operative between said abutment and said presser means and in parallel with said variable rate spring, a second spring adjustment operable for varying the compression loading on said pile due to said constant low rate spring, and an electro-magnet operative upon said presser means in opposition to said springs.

6. In an electric regulator of the carbon pile type, the combination of a resistance pile, presser means engaged with one end of said pile, a rigid abutment, a leaf spring operative between said abutment and said presser means for compressing said pile, said leaf spring being adapted for shortening its effective length and thereby attaining increased stiffness under increased compression, a substantially low rate coil spring operative between said abutment and said presser means and in parallel with said leaf spring, and an electro-magnet operative upon said presser means in opposition to said springs.

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