May 14, 1946. W. J. RADY 2,400,136

CARBON PILE REGULATOR

Filed Nov. 8, 1943 2 Sheets-Sheet 1

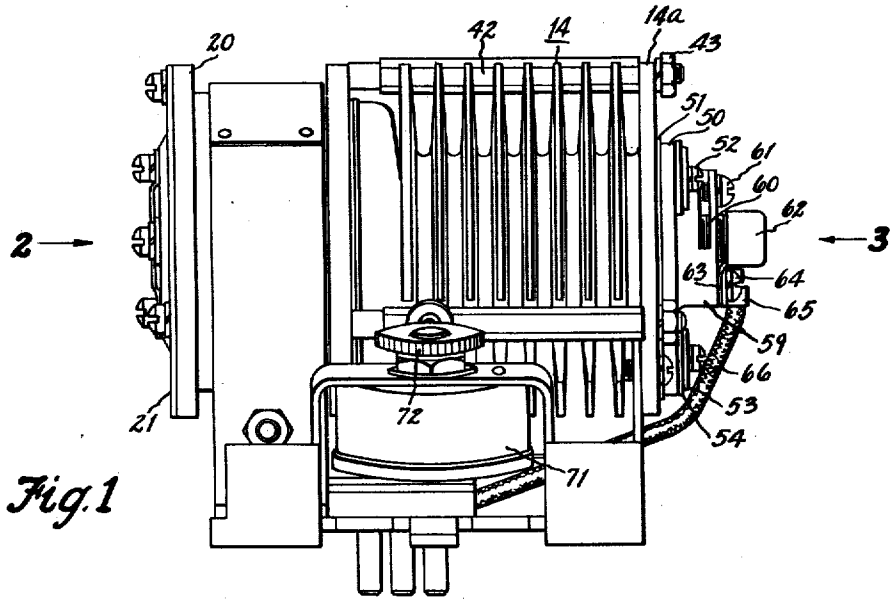


Fig. 1

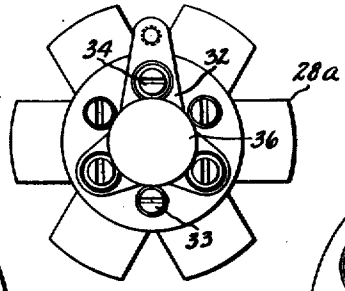


Fig. 4

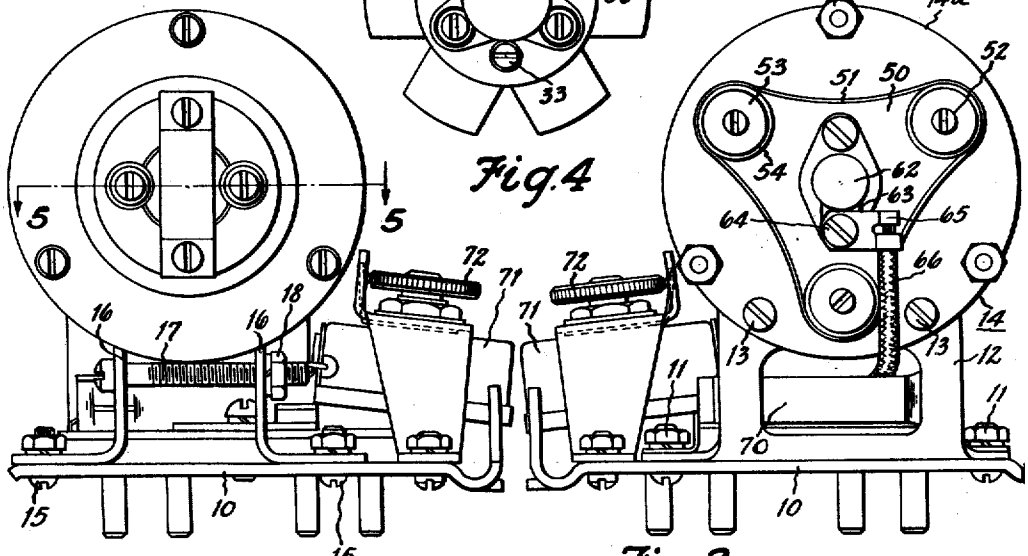


Fig. 2

Fig. 3

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CARBON PILE REGULATOR

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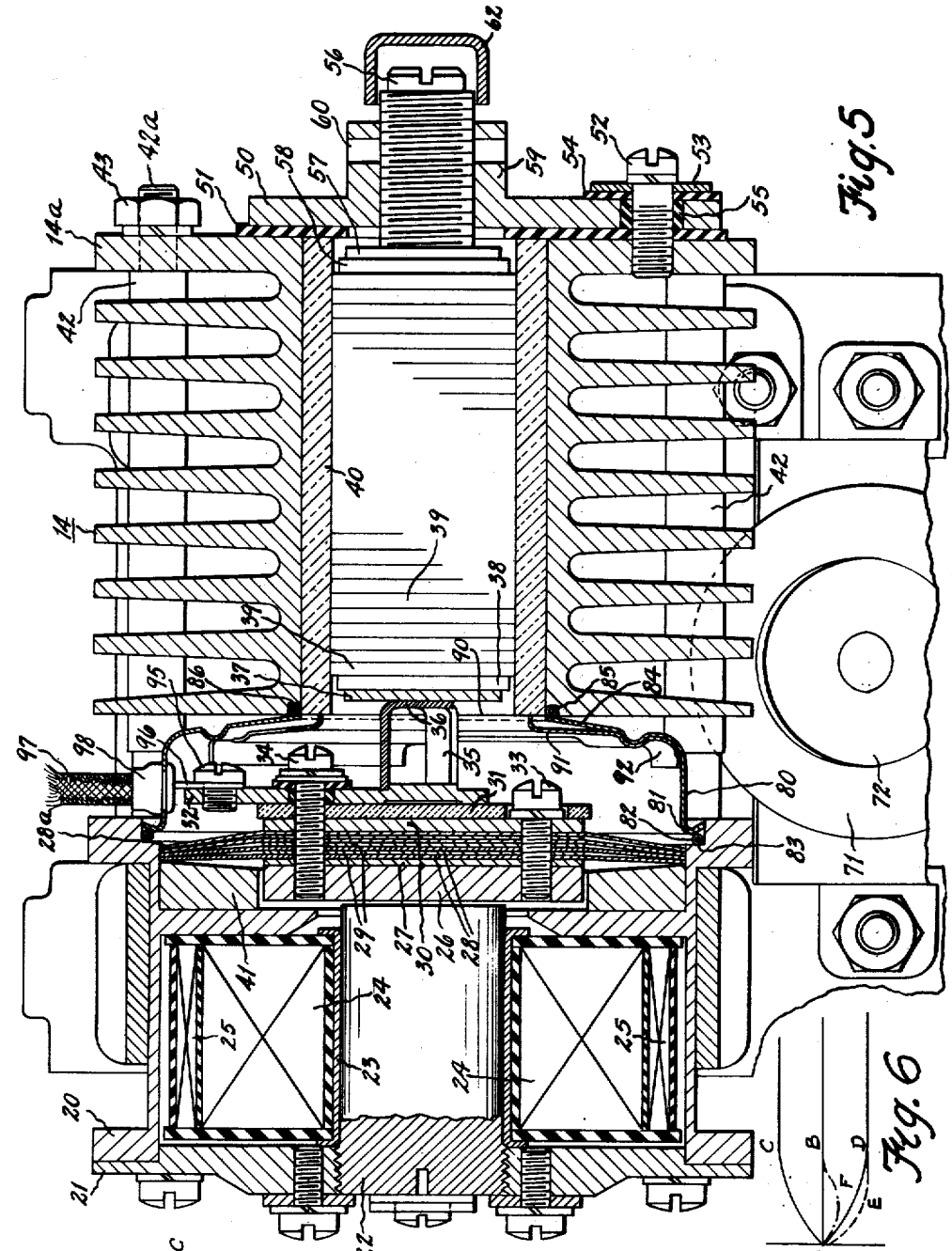


Fig. 5

Fig. 6

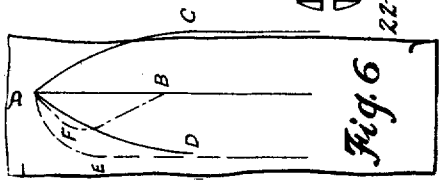


Fig. 6

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CARBON PILE REGULATOR

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Application November 8, 1943, Serial No. 509,454

6 Claims. (Cl. 201—51)

This invention relates to regulators for electric generators by which the voltage of the generator is maintained within prescribed limits. More particularly the present invention relates to a carbon-pile regulator comprising a stack of carbon discs connected in the generator field circuit and subjected to spring pressure and electromagnetic means responsive to generator voltage for varying the pressure between the discs.

It is well known that the operation of a regulator is affected by variations in the resistance of the electromagnet coil due to changes in temperature. Temperature responsive devices have been added to compensate for this variation in resistance. An object of the present invention is to provide compensation without adding a temperature responsive compensating device. In the disclosed embodiment of the invention, this object is accomplished by effecting, in response to increase of temperature of the regulator, a reduction of the modulus of elasticity of the control spring by an amount which compensates substantially for the increase in the resistance of the electromagnet coil due to increase in its temperature. In this connection, it is a further object so to retard the transfer of heat to the spring that it will not be heated faster than the electromagnet coil. Therefore, during change from environment temperature to operating temperature, the variation in regulating voltage will be minimized.

A further object is to provide for the complete enclosure of the working parts of the regulator in order to exclude foreign matter therefrom, while providing free relative movement between other parts due to variations in temperature.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred embodiment of the present invention is clearly shown.

In the drawings:

Fig. 1 is a side elevation of the regulator;

Figs. 2 and 3 are end views looking respectively in the directions of arrows 2 and 3 of Fig. 1.

Fig. 4 is a side view of the armature and spring assembly.

Fig. 5 is a longitudinal sectional view on line 5—5 of Fig. 2, and is drawn twice the size of the preceding views.

Fig. 6 is a graph in which curves are plotted to show the effect of temperature increase upon a carbon pile regulator.

Referring to Fig. 3, there is a base 10 to which screws 11 secure a bracket 12 attached by screws 13 to a heat-dissipating shell or radiator 14. Referring to Fig. 2, screws 15 secure to the base 10 the arms 16 of a clamp bracket which, by the tightening of a screw 17 cooperating with a nut 18, is caused to embrace tightly a magnetizable magnet shell 20 (Fig. 5).

Shell 20 supports a magnetizable plate 21 carrying an adjustable magnetizable core 22 supporting a metal tube 23 insulatingly supporting a main magnet coil 24 and an equalizer coil 25. Coil 25 is used when a plurality of generators using similar voltage regulators are connected with the same storage battery.

Core 22 cooperates with armature 26 which is part of an assembly comprising spacer 27, spring discs 28 having blades 28a, spacers 29, metallic disc 30, non-conducting discs 31 of mica, and terminal plate 32 attached to legs 35 of a strut 36. This assembly is secured together by screws 33 and 34. Spring blades 28a engage each other and the blades of the left hand disc 28 engage a ring 41 of copper or other non-magnetizable metal of good thermal conductivity.

Blades 28a urge the strut 36 against a metal disc 37 attached to a carbon button 38 thus placing a stack of carbon discs 39 under compression. Discs 39 are housed in a refractory tube 40 enclosed by the radiator 14.

The magnet housing 20 is tied to the remote end flange 14a of radiator 14 by studs 42 screwed into housing 20 and having threaded ends 42a passed through holes in flange 14a and receiving nuts 43. Terminal plate 50, attached by screws 52 to radiator 14, is insulated from the radiator 14 by a non-conducting plate 51 and from the screws 52 and metal washers 53 by insulating washers 54 and sleeves 55. Plate 50 carries a screw 56 attached to a metal disc 57, attached to a carbon button 58 which receives the pressure exerted by spring blades 28a on the stack of carbon discs 39. Screw 56 is adjustable to vary the normal pressure of blades 28a and the normal gap between armature 26 and core 22. The tubular screw-receiving portion 59 of plate 50 is split at 60 (Fig. 1) to provide a screw-thread clamp which is tightened by a screw 61. After screw 56 is adjusted, it is covered by a cup 62 having an ear 63 attached by a screw 64 used to secure to plate 50 a wire clip 65 attached to a wire 66.

The carbon stack is connected in series with the field of the generator to be regulated. Magnet coil 24 is in a circuit connected across the terminals of the generator, said circuit including a fixed resistance unit 70 (Fig. 3) and a variable resistance unit 71 controlled by a knurled disc 72.

The armature assembly is enclosed by a housing 80 having a flange 81 engaging a glass-fabric-covered metal ring 82 received by a shoulder 83 provided by magnet housing 20. Housing 80 has a flange 84 bearing against a glass-fabric-covered metal ring 85 received by a shoulder 86 provided by radiator 14. Housing 80 is resilient to provide for movement of the left end of radiator 14 relative to magnet housing 20. Tube 40, which ex-

pands faster than radiator 14, clears the flange 84 of housing 80 and bears against the flange 90 of a ring 91 having resilient branches 92 attached to housing 80.

Screw 95 secures to plate 32 the clip 96 of a wire 97 which passes through a bushing 98 attached to housing 80 and crimped around the insulation of wire 97.

Since the housing 20 is tied to that end of radiator 14 which is remote therefrom, expansion of radiator 14 does not affect the resistance of the carbon pile. Furthermore temperature variations in the carbon-pile do not materially affect the pressure thereon because the materials of the studs 42, strut 36 and disc 37 are so chosen that the studs 42 expand substantially the same amount as the combination of carbon-pile, disc 37 and strut 36.

The resistance of coil 24 increases as its temperature increases and its pull per volt on the armature 26 decreases. In order that regulation for the same voltage may be obtained as the temperature of the coil 24 increases, heat from the carbon-pile causes the blades 28a to expand thereby causing their moduli of elasticity to decrease at a rate which compensates for the increase in resistance in the coil 24. In other words, for a given temperature increase, the coil 24 and the blades 28a become proportionately weaker so that the regulator, whether cold or hot, will regulate for the same voltage.

In this connection it is important that the spring blades 28a should not be heated faster by the carbon pile, than the coil 24 is heated by the passage of electric current. Retardation for transfer of heat by conduction from the carbon pile to the springs is effected by the small cross-sectional dimensions of the legs 35 of strut 36 and by the thick mica insulating disc 31.

The heating of the blades 28a is limited due to the fact that the copper ring 41 is continually drawing out the heat from the blades and passing heat to the housing 20 from whence it is dissipated.

In order to demonstrate the functions of the heat-retarding strut 36 and the heat-absorbing ring 41, reference is made to Fig. 6 in which line A—B represents the voltage for which the regulator is set and line A—C represents the increase of regulated voltage due to heating the magnet coil by electric current. Line A—D represents the decrease in regulated voltage due to increase of spring temperature. Values C and D are those which exist at the end of the warm-up period when the differential of magnet coil and spring temperatures is practically constant thereafter. The ideal condition will exist if line A—D is the exact opposite of line A—C, the values D and C being the same and the slopes of the lines denoting rates of change of voltage due to temperature increase being the same. The function of the ring 41 is to absorb heat from the springs and to pass it on to the housing with which the ring is in close contact in order so to limit the heating of the springs that D, the final decrease in regulated voltage due to increase of spring temperature, will substantially equal C, the final increase in regulated voltage due to increase of coil temperature. The function of the strut 36 is so to limit the rate of transfer of heat from the carbon-pile to the springs that the rate of spring temperature increase is commensurate with the rate of coil temperature increase whereby the rate of regulated voltage decrease due to spring temperature increase, as represented by A—D is commensurate with the rate of regulated voltage increase due to coil temperature increase, as represented by A—C. While the mica insulating disc 31 has a retarding effect, it would not be effective to obtain a result approaching the effect represented by A—D without the strut 36 with its legs 35 which have relatively small cross-sectional dimensions and which provide relatively large radiating surfaces. Without the strut 36, heat from the carbon-pile would be transferred so rapidly to the springs that the decrease in regulated voltage due to spring temperature increase would be that represented, for example, by dash line A—E—D with the result that, during the warm-up period, there would be a sag in regulated voltage as represented, for example, by dot-dash line A—F—B.

While it is known that mica will retard transfer of heat, a body of mica having thickness sufficient to obtain an effect approximately the effect represented by line A—D, could not be used since mica softens with increase of temperature and its thickness would be substantially reduced under the pressure of the springs; and the distance between the carbon-pile and the springs and the armature would be changed.

In view of the foregoing, it is apparent that the use of the metal strut 36 makes it possible to use a mica disc of moderate thickness suitable for electrical insulation. Strut 36 so retards the heat transfer to the mica disc 31 that the softening effect of temperature increase therein is negligible. A strut having a plurality of spaced legs is relatively strong for the amount of material used in its construction. The cross-sectional dimensions of the legs are reduced to the minimum requirement of the spring pressure to be transmitted. The legs have relatively large heat-dissipating surfaces inside as well as outside so that not all the heat in the flat base of the strut passes into the plate 32. The strut 36 is therefore better adapted for the purposes of the present invention than a tubular strut such as disclosed in my Patent No. 2,354,542 while its elongation with increase in temperature compensates to a material degree in compensating for elongation of the studs 42.

While the embodiment of the present invention as herein disclosed, constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

What is claimed is as follows:

1. A carbon pile regulator comprising a housing; juxtaposed carbon discs forming a stack located within the housing; a refractory liner for aligning said discs; an electrode engaging one end of the stack and fixed relative to one end of the housing; an electrode engaging the other end of the stack and movable relative to the other end of housing; a frame located adjacent the last mentioned end of the housing in spaced relation thereto; an electromagnet supported by the frame; an armature cooperating with the electromagnet and attached to the movable electrode; biasing means for urging the armature toward the stack; a member for transmitting motion from the biasing means to the movable electrode adjacent thereto; a flexible closure having sealing engagement with the frame and the housing for completely enclosing the movable parts of the regulator so that same are not exposed to foreign matter; and resilient member supported by the closure and having a suspended central portion

engageable with the liner to permit free movement of the liner relative to the closure.

2. A carbon pile regulator comprising a casing; a refractory tube supported within the casing; juxtaposed carbon discs forming a stack or pile located within the tube; an electrode engaging one end of the pile and fixed relative to one end of the casing; an electrode engaging the other end of the pile and movable relative to the other end of the casing; a frame located adjacent the last mentioned end of the casing; means for securing the frame to the casing in spaced relation thereto; an electromagnet supported by the frame; an armature cooperating with the electromagnet and attached to the movable electrode; resilient means operatively connected with the frame and with the armature for urging the armature toward the pile; a member for transmitting motion from the resilient means to the movable electrode adjacent thereto; and a flexible enclosure disposed between casing and the frame for completely enclosing the movable parts so that same are not exposed to foreign matter, said enclosure providing a cylindrical portion coaxial of said tube and engageable therewith to permit free movement of the tube relative to the enclosure.

3. A carbon pile regulator comprising a housing having one end relatively fixed and the other end free of obstruction to elongation or contraction due to temperature change; a stack of carbon discs located within the housing; an electrode attached to the relatively fixed end of the housing and engaging one end of the stack; a movable electrode engaging the other end of the stack; a frame located adjacent the free end of the housing; means for securing the housing to the frame in spaced relation thereto; an electromagnet supported by the frame; an armature cooperating with the electromagnet and attached to the movable electrode; resilient means operatively connected with the frame and with the armature for urging the armature toward the pile; a member for transmitting motion from the resilient means to the movable electrode adjacent thereto; a pair of fabric rings one supported by the housing the other by the frame; a flexible member disposed between the housing and the frame for completely enclosing the movable parts of the regulator so that same are not exposed to foreign matter, said enclosure providing a cylindrical portion at each end thereof with each cylindrical portion engaging one of the fabric rings to form effective seals between the enclosure and the housing and the frame.

4. A carbon pile regulator comprising a housing including a refractory liner; said housing having one end relatively fixed and the other end free of obstruction to elongation or contraction due to temperature change; a stack of carbon discs supported within the housing; an electrode engaging one end of the stack and fixed relative to one end of the housing; an electrode engaging the other end of the stack and movable relative to the other end of the housing; a frame located adjacent the last mentioned end of the housing in spaced relation thereto; an electromagnet supported by the frame; an armature cooperating with the electromagnet and attached to the movable electrode; biasing means for urging the armature toward the stack; a member for transmitting motion from the biasing means to the movable electrode adjacent thereto; a pair of insulated covered rings, one supported by the frame and the other by the housing; a flexible cover disposed between the frame and the housing for completely enclosing the movable parts of the regulator, said cover having annular flange portions at each end thereof with each flange engaging one of the rings to provide seals to prevent foreign matter from entering the interior of the cover; and a resilient member having arms attached to the interior of the cover and having a cylindrical portion engageable with the liner to permit free movement of the liner relative to the cover.

5. An electrical regulator comprising a frame, a stack of resistance discs supported by the frame, force applying means for compressing the stack and comprising an abutment member mounted on the frame in close contact therewith, spring means bearing on the abutment member and means for transmitting force from the spring means to the stack, electromagnetic means for opposing the spring means and comprising a magnet coil supported by the frame and an armature connected with the spring means, said force-transmitting means including a strut of relatively small cross-sectional dimensions and relatively large heat dissipating surface area and providing for a relatively low rate of transfer of heat from the stack to the spring means, said abutment member having relatively high thermal conductivity and relatively large area of contact with the frame, said force-transmitting means by virtue of its ability to limit transfer of heat from the stack to the spring means and said abutment member by virtue of its ability to extract heat from the spring means cooperating so to limit the temperature increase of the spring means, in rate and amount, that the corresponding decrease in modulus of elasticity of the spring means is proportional to the increase in resistance of the magnet coil whereby, during the warm-up period, variations in regulated voltage due to temperature variation are minimized.

6. An electrical regulator comprising a frame, a stack of resistance discs supported by the frame, means for applying pressure to the stack and comprising leaf spring members, a fixed abutment member mounted on the frame and in close contact therewith and having relatively high thermal conductivity and relatively large area of contact with the frame, and means for transmitting force from the springs to the stack and including a strut having spaced legs of relatively small cross-sectional dimensions and relatively large heat dissipating surface area and providing for a relatively low rate of transfer of heat from the stack to the springs, electromagnetic means for opposing the springs and comprising a magnet coil supported by the frame and an armature connected with the springs, said force-transmitting means by virtue of its ability to limit transfer of heat from the stack to the springs and said abutment member by virtue of its ability to extract heat from the springs cooperating so to limit the temperature increase of the springs, in rate and amount, that the corresponding decrease in modulus of elasticity of the springs is proportional to the increase in resistance of the magnet coil whereby, during the warm-up period, variations in regulated voltage due to temperature variation are minimized.

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