April 16, 1946. L. W. THOMPSON 2,398,679

RESISTANCE REGULATOR

Filed March 18, 1943 2 Sheets-Sheet 1

Fig. 1.

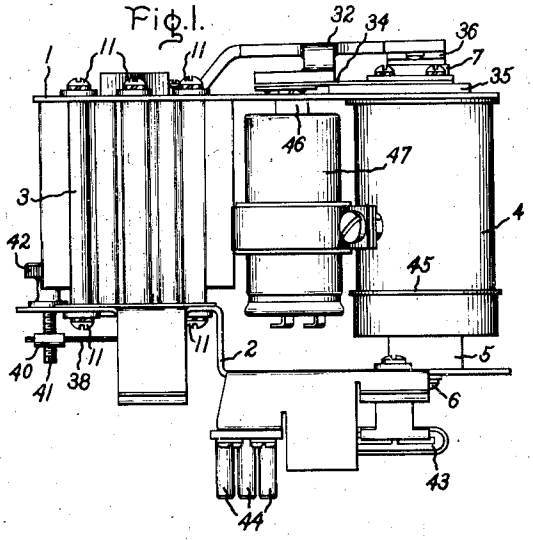


Fig. 2.

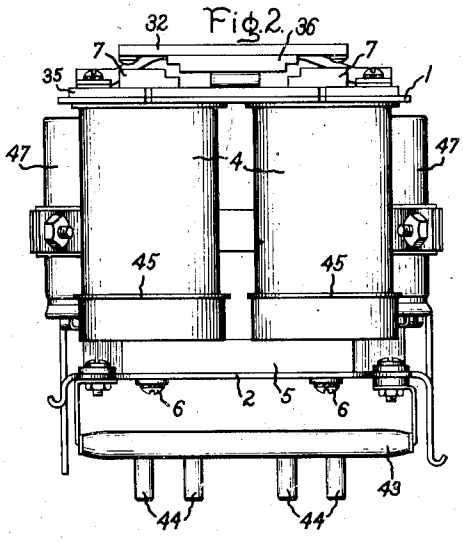


Fig. 3.

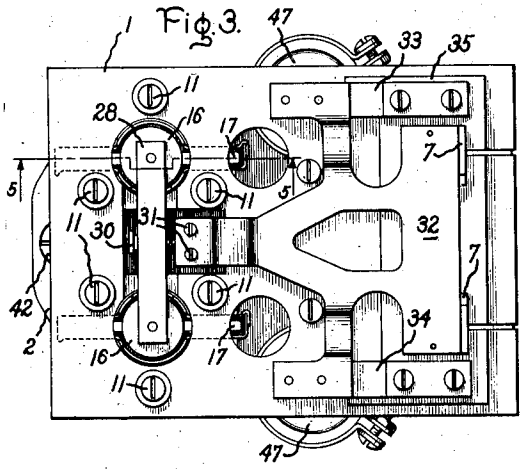


Fig. 4.

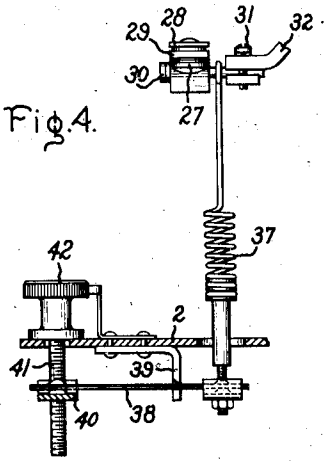


Fig. 5.

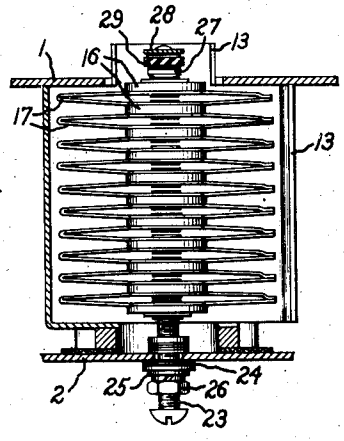
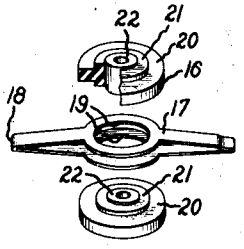


Fig. 6.



Inventor:
Louis W. Thompson,
by Harry E. Dunham
His Attorney.

April 16, 1946. L. W. THOMPSON 2,398,679

RESISTANCE REGULATOR

Filed March 18, 1943 2 Sheets-Sheet 2

Fig. 7.

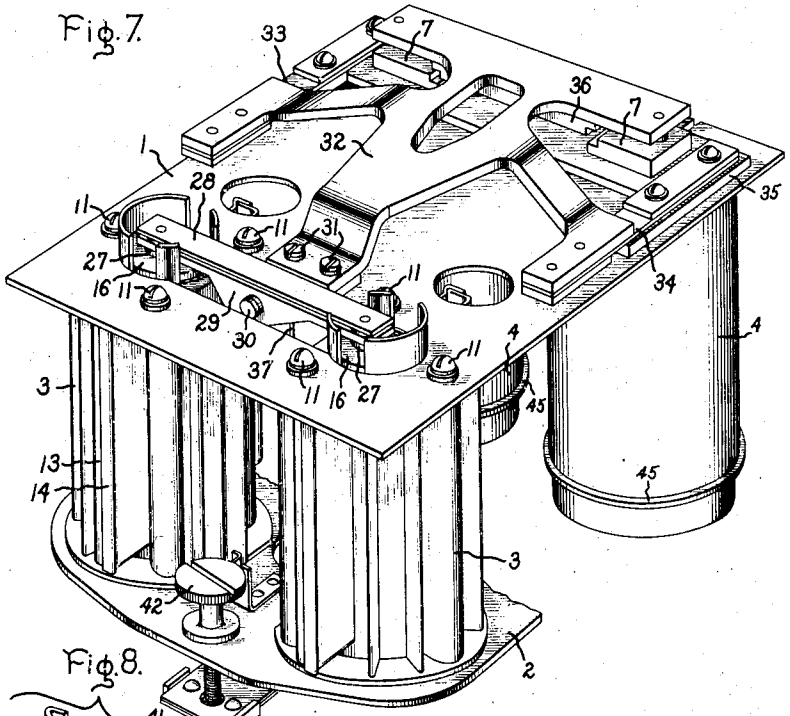


Fig. 8.

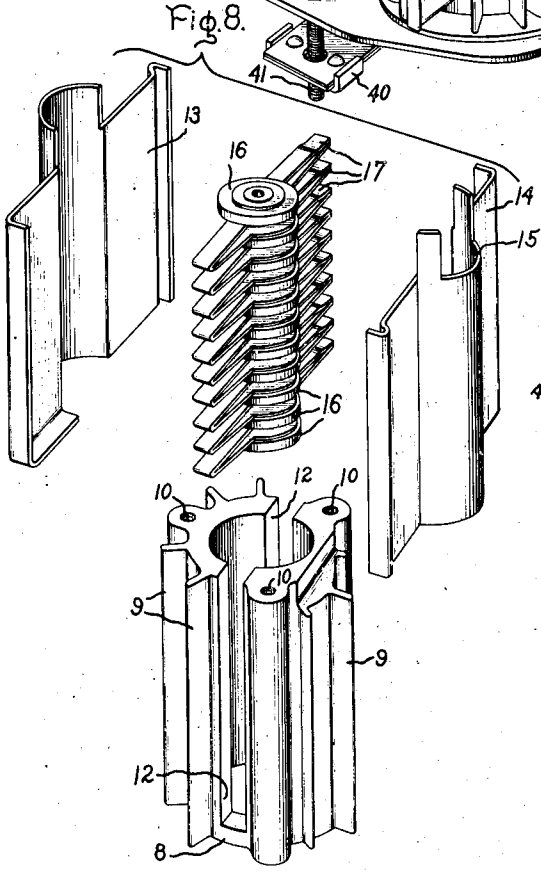
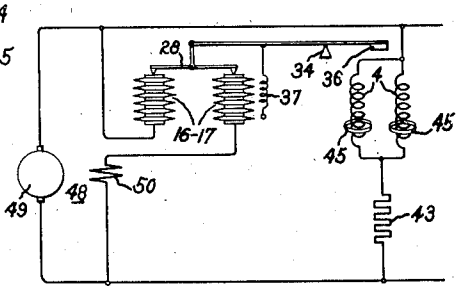


Fig. 9.



Inventor:
Louis W. Thompson,
by Harry E. Dunham
His Attorney.

Patented Apr. 16, 1946 2,398,679

UNITED STATES PATENT OFFICE

2,398,679

RESISTANCE REGULATOR

Louis W. Thompson, Schenectady, N. Y., assignor to General Electric Company, a corporation of New York

Application March 18, 1943, Serial No. 479,633

4 Claims. (Cl. 201—51)

This invention relates to resistance regulators and more particularly to an improved stable and rugged direct-acting automatic resistance regulator.

By "direct-acting" is meant that the primary or main electroresponsive control means for the regulator actuates the rheostatic or variable resistance means directly and not through any intermediate servo or power amplifying mechanism.

The rheostatic portion of the regulator is an enclosed compressible pile comprising alternate resistance elements of carbon or the equivalent and metal springs which not only act as cooling fins for the resistance element but also permit low resistance contacts on the resistance elements to engage each other through axially aligned openings in the springs.

An object of the invention is to provide a new and improved electric regulator.

Another object of the invention is to provide a compact and simple automatic direct-acting rheostatic regulator.

A further object of the invention is to provide an improved, rugged and stable direct-acting rheostatic generator voltage regulator.

An additional object of the invention is to provide an improved wide-range high-capacity regulating resistance.

The invention will be better understood from the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims.

In the drawings, in which the same reference character designates the same element throughout the several views, Fig. 1 is a side elevation of a preferred form of the invention, Fig. 2 is an end elevation of the same regulator when looking from right to left of Fig. 1, Fig. 3 is a plan view of the regulator, Fig. 4 is a detailed view showing the adjusting and temperature compensating elements of the regulator, Fig. 5 is a sectional view taken on the line 5—5 of Fig. 3, Fig. 6 is an exploded detailed view of the components of the resistance device, Fig. 7 is a perspective view of the regulator, Fig. 8 is an exploded view of one of the two rheostatic elements of the regulator, and Fig. 9 is a circuit diagram of the electrical connections of the regulator.

Referring now to the drawings, the regulator is structurally similar to a parallelogram in that it comprises upper and lower main frames or supporting plates 1 and 2 which are held apart by a pair of similar rheostatic elements 3 at one end and a pair of operating electromagnets 4 at the other end. As shown more clearly in Figs. 1 and 2, the coils of the electromagnets are mounted on a U-shaped core whose transverse portion 5 is attached to the lower plate 2 by screws 6 and whose legs are surrounded by the coils and terminate at their upper ends in pole pieces 7.

As shown most clearly in Figs. 1, 7 and 8, the rheostatic elements each comprise an outer casing or cylinder 8 which is made of metal and which is provided with radially extending cooling fins 9. The top and bottom surfaces of this cylinder are flat and they are provided with three substantially equally spaced tapped poles 10 into which screws 11 are threaded at both ends for clamping the respective upper and lower plates 1 and 2. The remaining details of the rheostatic elements are shown most clearly in Figs. 5, 6 and 8. The cylinder 8 is provided with diametrically opposite slots 12 into which is fitted a liner comprising two pressed metal pieces 13 and 14 which have substantially duplicate shapes and are so constructed that they fit together to make a closed container. The inner surfaces of these liners are provided with a heavy enamel coating which acts as an insulator. The only difference between members 13 and 14 is that member 14 has a cutaway section 15 at the top for enabling the linkage which actuates the rheostatic elements to pass therethrough. Mounted within the liner is a stack or pile of alternate resistance elements 16 and blade spring members 17. The resistance elements are preferably composed of carbon or the equivalent and the blade springs are composed of metal, such as stainless steel or "Nichrome." The resistance elements are circular in cross section and have a diameter slightly less than the inner diameter of the opening formed by the central portion of the liner when its two parts are fitted together. The spring members are made from flat strip stock and they are bent double at 18, as shown in Fig. 6 and the two halves are provided with openings 19 shown as being formed by enlarged ring-shaped sections integral with the springs. The resistance elements have flat shoulders 20 from which rise short projections 21 and these projections fit into the aligned openings of the springs so that the flat circular portions surrounding the openings of the springs make continuous contact with the flat shoulders 20 of the resistance elements. The outer diameters of the circular ring-shaped members in the springs are preferably slightly less than the diameter of the resistance elements so that the former are held out of contact with the inner enameled surface of the cylinder liner.

If now variable pressure is applied axially between the ends of the pile or stack, as shown, for example, in Fig. 5, the pressure between the shoulders of each of the resistance elements and the springs making contact therewith will vary thereby not only varying the pressure to which the carbon resistance elements are subjected but also varying the pressure between the contact surfaces of the carbon and metal so that not only does the electrical resistance of the resistance elements themselves change but also the electrical resistance of the contact resistance between the metal to carbon contacts changes.

In order to make the resistance substantially zero when full pressure is applied the resistance elements 16 are provided with axial contact plugs 22 which pass axially through the elements and which terminate in flat contact faces extending slightly above the surface of the projections 21 and also extending slightly beyond the surface of the spring members 17 when they are in position, as is shown in Fig. 5. In this manner when full pressure is applied the low resistance contact faces are all in engagement so that the stack is short circuited and its resistance is substantially zero. The plugs 22 may be made of any suitable low resistance material, such, for example, as silver.

Electrical connection is made to each rheostat stack at the bottom by means of a screw 23 which is clamped to the lower plate 2 but which is insulated therefrom by insulating washers 24, the electrical connection from the screw 23 being made by a terminal 25 clamped between the insulating washer 24 and a nut 26. Electrical connection at the upper end of the rheostat stacks is made by means of pressure applying contacts 27, both of which are directly connected together by a low resistance conducting bar 28 fastened to the top of an insulating yoke member 29. The latter is pivotally mounted on a pin 30 which is held by two screws 31 in an armature assembly or frame 32.

The force of the operating magnets 4 is transmitted to the rheostat stacks by means of the frame 32 which is effectively pivoted to the upper plate 1 at opposite points 33 and 34. These pivot points are frictionless and comprise flat spring blades or strips clamped between the moving frame 32 and block 35 on the upper plate 1.

The end of the frame 32 which is over the pole pieces 7 carries a pole piece 36. In order to increase the stability of the regulator the electromagnetic pull on the movable armature 36 as the air gap decreases is prevented from increasing as rapidly or in as nonlinear a manner as with conventional magnets by notching or stepping the adjacent faces of the pole pieces 7 and 36. By means of this construction as the pole piece 36 moves downwardly, as viewed in Fig. 2, under the influence of an increased energization of the coils of the magnets the flux between the pole pieces will tend to be deflected from the substantially vertical to the substantially horizontal because the shortest air gaps will be between the vertical portions of the teeth as they slide relative to each other. The horizontal components of flux will not produce any downward pull on the armature so that the shortening of the air gap will be accompanied by a diversion or deflection of the flux.

The normal pull of the operating magnets is opposed by a spring 37, shown most clearly in Fig. 4. The upper end of this spring is attached to the pin 30 and the lower end is attached to a lever 38 which is pivotally mounted in a frame 39 attached to the lower plate 2. The outer end of the lever 38 carries a nut 40 which moves on a screw 41 provided in a knurled head 42 for adjusting the spring tension and thereby adjusting the setting of the regulator.

In order to compensate the regulator for the effects of variation in temperature, some of which are the change in resistance of the windings of the operating magnets and the change in dimensions of the various parts, the lever 38 is a bimetallic strip which bends with changes in temperature in such a manner that the resultant changes in spring tension compensate for the effect of variations in temperature on the other elements of the regulator.

The spring 37 is always sufficiently strong to provide full compression of the resistance stacks when the magnets are de-energized and the knob 42 is usually adjusted so that when the energization of the magnets corresponds to the normal value of the quantity to be regulated the armature 36 will float within a range of positions limited by the maximum and minimum resistance positions.

In order to provide further temperature compensation and in order to limit the voltage on the windings of the operating magnets a fixed resistor 43 is mounted on brackets depending from the lower side of the lower plate 2 and this resistor is connected in series with the windings of the magnets.

The external connections to the regulator are conveniently made by means of pins 44 which are adapted to fit into a suitable receptacle or socket connector.

In order further to improve the stability of the regulator each of the electromagnets is provided with a short circuited turn of low resistance, such as a ring of copper 45 which inherently opposes any change in flux in the magnetic circuit of the magnets.

Shown clamped to a depending projection 46 from the upper plate 1 are a pair of capacitors 47 which comprise elements of an anti-hunting circuit for the regulator which forms no part of the present invention.

The regulator may conveniently be connected to maintain constant the voltage of a variable speed and variably loaded direct-current generator 48, as shown in Fig. 9. This generator has an armature 49 across whose output circuit the two electromagnets 4 are connected in parallel with each other and in series with the resistor 43. The generator is shown, for example, as being provided with a shunt field winding 50 in series with which the two rheostatic stacks 16—17 are connected, the two stacks also being in series with each other.

In operation if the voltage of the generator increases above normal the pull of the electromagnets exceeds the pull of the spring 37 thereby decreasing the pressure and consequently the resistance of the rheostat elements whereby the excitation of the generator is decreased and its voltage is restored to normal. Similarly, a decrease in voltage will cause the spring pull to be stronger than the magnetic pull, thereby decreasing the resistance of the regulator and increasing the excitation sufficiently to return the voltage to normal.

While there has been shown and described a particular embodiment of this invention, it will be obvious to those skilled in the art that vari-

ous changes and modifications can be made therein without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A resistance regulator comprising, in combination, a plurality of flat relatively thin and long metal spring strips each provided with two openings and being bent double midway between said openings so that said openings are in alignment, a plurality of resistance elements having flat shoulders from which extend projections on opposite sides which are adapted to fit into said openings, said bent spring strips and resistance elements being alternately interleaved with the projections of said resistance elements in the openings in said spring strips and with the shoulders of said resistance elements in contact with the outer surfaces of said spring strips whereby an electric current in flowing through said regulator will normally flow alternately through said resistance elements and spring strips in series, low resistance conductors mounted in said resistance elements and terminating in contact faces which extend beyond said projections, and means for compressing said spring strips so as to bring the low resistance contact faces of the resistance elements on opposite sides of said strips into contact.

2. In combination, a metal cylinder provided with integral cooling fins, a pair of longitudinal slots in said cylinder, an insulating liner fitted into said cylinder, said liner having hollow extensions which fit into said slots, a plurality of resistance elements loosely fitted into said liner, said elements having a cross sectional configuration similar to that of said liner, a plurality of bent metal spring blades mounted between said resistance elements and extending into the hollow extensions of said liner, said spring blades having openings and said resistance elements having projections fitted therein for keeping said blades in alignment and out of contact with said liner, low resistance conductors passed through said resistance elements and terminating in contact faces on opposite sides thereof which are within the openings in said blade springs, and means for applying pressure axially of said cylinder for compressing said springs so as to bring said contact faces into engagement.

3. A resistance regulator comprising, in combination, an electromagnet having a pole piece, a rheostatic element, a spring for compressing said element, a pivoted armature which carries a pole piece which is magnetically attracted by the pole piece of said magnet and which exerts a force opposite to that of said spring on said rheostatic element, said pole pieces having interfitting teeth with sides parallel to their direction of relative motion whereby as the pole pieces approach each other the direction of the major portion of the magnetic flux therebetween is deflected from substantial parallelism with their direction of relative motion and the nonlinearity of their pull-position characteristic is materially reduced.

4. A rheostatic device comprising, in combination, a plurality of carbon resistance elements, means including a plurality of U-shaped metal blade springs having two legs arranged alternately with said resistance elements in a straight row with the outer sides of said two legs of each spring in contact with two different resistance elements for biasing apart adjacent resistance elements, and separate mechanical means for variably compressing said row of alternate springs and elements.

LOUIS W. THOMPSON.