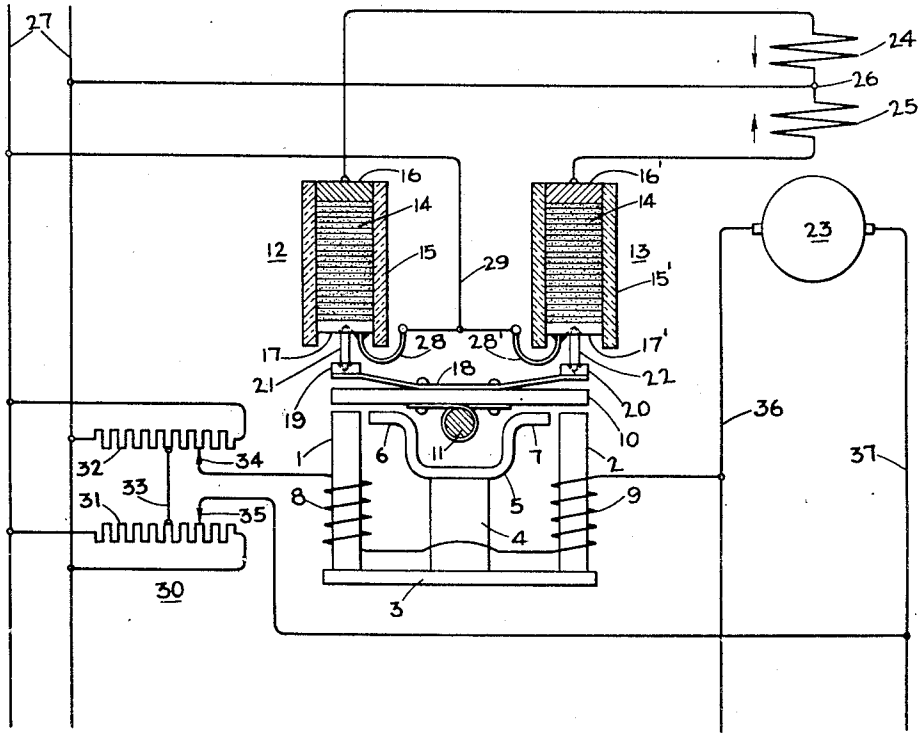
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VOLTAGE REGULATING APPARATUS

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VOLTAGE REGULATING APPARATUS

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My invention relates to voltage regulating apparatus for dynamo-electric machines, and more particularly to a sensitive and fast acting regulating system employing the carbon pile or pressure responsive type of voltage regulator.

One of the chief disadvantages in the use of pressure responsive regulators, such as those of the carbon pile type, has been the comparatively limited range over which the resistance change may be effected. In other words, the range of pressure which is practicable to obtain in a device of limited size and cost of this nature is not sufficient to result in as wide a range of resistance values as is desirable for the effective regulation of dynamoelectric machines. It is also desirable to provide a regulator that will adjust the field excitation rapidly from zero to the maximum desired value, and in addition which possesses the ability to reverse the field excitation in the event that extreme generator overvoltage occurs, so that generator voltage will be quickly forced or restored to the proper level.

Accordingly, it is an object of my invention to provide an improved voltage regulating system for dynamoelectric machines.

It is another object of my invention to provide improved regulating means for dynamoelectric machines in which the field excitation may be rapidly and smoothly varied from minimum to maximum values.

It is a further object of my invention to provide an improved form of pressure-actuated resistance-type voltage regulator having a wide range of resistance value adjustment.

It is a still further object of my invention to provide an improved type of carbon pile voltage regulator and regulating system therefor, in which maximum adjusting range and extreme sensitivity are obtained.

For a more complete understanding of my invention, reference should now be had to the accompanying drawing, and its scope will be pointed out in the appended claims.

The drawing shows a diagrammatic illustration of a voltage regulating device according to my invention together with a control system showing its application.

Referring now to the drawing, I have shown a rheostatic regulator device of the carbon pile type having a magnetic frame comprising the pole pieces 1 and 2 connected by a magnetic support 3 and provided with a block 4 of permanent magnet material of high coercivity and retentivity forming a permanent magnetic excitation source. Supported on the block 4 is a yoke 5 having outwardly turned ends 6 and 7 disposed in proximity with the upper ends of the pole pieces 1 and 2, respectively. For energizing the pole pieces 1 and 2 to actuate the device,

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exciting windings 8 and 9, respectively, are disposed around the pole pieces.

An armature 10 of magnetic material is pivotally mounted at its midpoint by a pivot 11 so that the end portions of the armature 10 are in alignment with and co-operate with the pole pieces 1 and 2. The arrangement is such that movement of one end of the armature 10 toward its related pole piece will result in movement of the opposite end of the armature away from its associated pole piece. The armature 10 is arranged to vary the pressure applied to a pair of compression type resistance elements 12 and 13, each of which consists of a stack of carbon discs 14 loosely contained within the porcelain tubes 15 and 15'. At the upper end of each tube fixed abutment members 16 and 16' of conducting material are provided which form an electrical contact surface as well as a mechanical stop. At the lower end of each of the porcelain tubes movable abutment members 17 and 17' of electrical conducting material are provided and are capable of axial movement within the tube to vary the pressure applied to the stack of carbon discs. A spring blade 18 is secured to the armature member 10 and carries support members 19 and 20, respectively, at each end thereof which are provided with conical recesses into which are fitted compression pins 21 and 22, respectively. By this means force or pressure is transmitted from the armature 10 to the movable abutment 17 or 17', as the case may be, depending upon the direction of movement of the armature.

The device is shown as applied to controlling the field excitation of a direct current generator 23 which is provided with a split field winding having two sections 24 and 25 of equal number of turns, and provided with a center tap 26. The circuit is arranged so that the magnetic effect of the two halves 24 and 25 of the field winding are opposite in polarity and of equal magnitude when equal currents are flowing through each half of the winding as shown by the directional arrows placed alongside the field windings. The field windings are supplied with direct current energy from a substantially constant unidirectional reference voltage source (not shown) through the auxiliary supply conductors 27, each winding having in series therewith one resistance element of the carbon pile regulator. The circuit is completed through the lower movable abutments 17 and 17' of each carbon pile which are electrically connected by the flexible connectors 28 and 28', through conductor 29 to the supply line 27. Assuming that the armature 10 is in the neutral or balanced position as shown, the pressure will be equal on each of the carbon piles, and equal current will be flowing from the supply line to each half of the field windings

24 and 25 and back to the supply line through the center tap connection 26.

For increasing the sensitivity of the carbon pile regulator, a reversing potentiometer 30 is provided which consists of the resistors 31 and 32 connected across the supply line and connected at their midpoints by the balancer connection 33. A pair of adjustable contacts 34 and 35 are provided for tapping off any desired voltage between zero and full line voltage of the supply line 27. It will be noticed that the regulator control coils 8 and 9 are connected in series between one line 36 of the generator 23 and the movable contact on potentiometer 34, whereas the other line 37 of the generator is connected directly to the other movable contact 35 on the potentiometer. Thus, the voltage applied to control coils 8 and 9 is the algebraic sum of the voltage of the generator and voltage derived from the potentiometer, and the flux produced by the coils 8 and 9 is therefore proportional to the algebraic sum of the generator voltage and the potentiometer voltage. The flux established in the cores 1 and 2 by the windings 8 and 9, respectively, will, since the windings 8 and 9 are in opposition, add to the flux established in one pole by the permanent magnet 4 and subtract from the flux established in the other pole by the permanent magnet 4 to an extent determined by the difference between the generator voltage and the potentiometer voltage.

Assuming that there is little or no voltage output from the generator 23 and that the adjustable contacts 34 and 35 are displaced from their zero position, as shown in the drawing, a definite voltage will then be derived from the potentiometer, causing current to flow into coils 8 and 9 and unbalancing the magnetic force acting on the armature member 10 in a sense to cause one end of the armature 10 to be attracted towards one pole piece and the other end to be attracted to the other pole piece, thereby reducing the pressure on one corrsponding carbon pile and increasing the pressure on the other carbon pile. This will, in turn, reduce the resistance in the carbon pile to which pressure is applied, with a consequent increase in current flow in its corresponding field winding and an equal and opposite decrease in current flow in the other field winding. The net flux produced in the two halves of the field winding will, therefore, vary to a much greater extent than the original displacement of the movable armature or of the voltage change inducing such displacement. It has been assumed that the net excitation of the field winding just described, is in a direction to cause an increase in generator voltage. The voltage produced by the generator 23 is opposed to that derived from the potentiometer, so that as the generator voltage rises the effective net voltage applied to the control coils 8 and 9 will be decreased, with a resultant change in position of the armature member 10 of the regulator. This change is, therefore, in a direction to reduce pressure on one pile while increasing pressure on the other carbon pile, and in a sense to equalize the currents flowing in the two halves of the generator field winding. Thus, the system rapidly reaches a point of equilibrium which is the required regulated voltage desired to hold on the main generator, in which the net excitation of the field winding is just sufficient to hold the generator voltage at a proper level. Any change in generator voltage due to fluctuating machine speed or change in load conditions is, therefore, effective to vary the voltage applied to the control coils, since the voltage output of the potentiometer is constant

and the change will always be in a direction to actuate the armature member in the proper sense to increase or decrease net excitation of the generator field winding to correct the original change in generator voltage.

The use of a split field winding of this type, together with the double acting carbon pile regulator, permits extremely rapid and sensitive adjustment of the generator field current since at balanced conditions the generator field net exciting current excitation is stable. Any slight change, therefore, in the position of the armature 10 is accompanied by a proportional increase in resistance of one field winding and decrease in the other, which results in an amplified or enhanced change in the net exciting flux in the generator field winding approximating a 2:1 change ratio.

The control potential established by the contacts 34 and 35 will normally be set at a value somewhat higher than the desired regulated generator voltage so that all voltage fluctuations up to the control voltage potential will operate to maintain the net field flux in the split field winding in one direction but of varying magnitude. This also permits the regulator to reverse the net field flux in the event voltage surges or transients on the generator 23 exceed the preset control potential on the potentiometer 30. In this case the current through the regulator exciting windings 8 and 9 would be reversed, with the result that the net excitation supplied by the split field winding will reverse, thereby operating rapidly to reduce such transients and overvoltages from the generator output. The regulator and associated control circuit are easily adapted to voltage regulation of any range of machine, since the reversing potentiometer may be adjusted to any desired preset voltage and if the generator 23 happens to be a high voltage machine, control voltage for energizing coils 8 and 9 may be obtained by the use of a potentiometer or voltage divider placed across the generator conductors 36 and 37.

It will be obvious to those skilled in the art that in cases where the reversing feature and increased sensitivity are not required, the potentiometer 30 may be omitted entirely and the control coils 8 and 9 energized directly from the generator leads 36 and 37, in which case the regulating device is then adjusted so that its armature member is in the balanced or midpoint position at the value of generator voltage corresponding to rated or standard.

Another modification that will be apparent is the replacement of the permanent magnet 4 of the regulator by an electromagnet having a suitable exciting winding which may be conveniently supplied from the constant voltage supply course 27. An adjusting resistor can then be provided to vary the fixed or basic magnetization of the regulator magnetic structure to provide any desired degree of sensitivity.

It will, therefore, be apparent that the regulator and system as illustrated and described provide extremely accurate and sensitive control means for adjusting generator voltage or maintaining the generator voltage constant at a desired value. Another advantage is the use of the reversing potentiometer by which generator excitation may be made to reverse in the event of overvoltage on the generator, thereby providing a rapid forcing action to restore the generator voltage to the proper level.

While I have shown and described a particu-

lar embodiment of my invention, it will be obvious to those skilled in the art that changes and modifications may be made without departing from my invention in its broader aspects, and I, therefore, aim in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

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

1. A regulating device for an electric circuit comprising, a pair of pressure responsive resistance elements connected in said circuit for controlling the flow of current therein, an E-shaped magnetic frame having a central leg of polarized magnetic material and a pair of outer legs of magnetizable material, an exciting coil on each of said outer legs, a yoke member affixed to said central leg and extending from said central leg to a point in proximity with each of said outer legs thereby providing a double magnetic flux path, a magnetizable armature pivoted adjacent said central leg with its opposite ends in cooperative relationship with said outer legs, mechanical linkage conecting said magnetizable armature to said pressure responsive elements and operative during motion of said armature to apply pressure to one of said elements while simultaneously releasing pressure on the other of said elements, and tension means associated with said linkage for maintaining a positive amount of compression on said pressure responsive elements at all times.

2. A regulating device for an electric circuit comprising, a pair of pressure responsive resistance elements connected in said circuit for controlling the flow of current therein, an E-shaped magnetic frame having a central leg of polarized magnetic material and a pair of outer legs of magnetizable material, exciting coils for said outer legs, a yoke member affixed to said central leg and extending from said central leg to a point in proximity with each of said outer legs thereby providing a double magnetic flux path, a magnetizable armature pivoted adjacent said central leg for oscillating movement to or from one of said outer legs, mechanical linkage connecting said magnetizable armature to said pressure responsive elements and operative upon movement of said armature to apply pressure to one of said elements while simultaneously releasing pressure on the other of said elements, and spring means associated with said linkage for maintaining a compressive force on said pressure responsive elements at all times.

3. A regulating device for an electric circuit comprising, a pair of pressure responsive carbon pile resistances connected in said circuit for controlling the flow of current therein, an E-shaped magnetic frame having a central leg of polarized magnetic material and a pair of outer legs of magnetizable material, a yoke member secured to said central leg and extending outwardly from said central leg toward each of said outer legs thereby providing a double magnetic flux path, exciting coils on said outer legs for providing a flux in one of said legs that opposes said flux produced by said polarized central leg and that aids said last mentioned flux in the other of said outer legs, a magnetizable armature pivoted adjacent said central leg and cooperating with said outer legs at its ends, and mechanical means connecting said magnetizable armature to said pressure

responsive resistances and operative upon movement of said armature to apply pressure to one of said elements while simultaneously releasing pressure on the other of said elements.

4. An electrical voltage regulating device comprising, a pressure responsive variable resistance element, mechanical means effective to vary the pressure on said element, said mechanical means including a pivoted balanced armature of magnetic material, a magnetizable frame positioned in operative relationship to said armature, said armature completing a pair of flux paths including said frame and opposite ends of said armature respectively, magnetizing means for establishing a substantially constant component of magnetic flux in both said paths, and electromagnetic energizing means on said frame for increasing the intensity of the flux in one of said paths and simultaneously decreasing the intensity of the flux in the other of said paths.

5. An electrical voltage regulating device comprising, a pair of pressure responsive variable resistance elements, mechanical means effective to vary the pressure on each of said elements simultaneously and in the opposite sense, the pressure on one of said elements being increased as the pressure on the other said element is decreased, said mechanical means including a pivoted balanced armature of magnetic material, a magnetizable frame positioned in operative relationship to said armature for varying the position of said armature, said armature completing a pair of flux paths including said frame and opposite ends of said armature respectively, magnetizing means for establishing a substantially constant component of magnetic flux in both said paths, and electromagnetic energizing means on said frame for varying the intensity of the flux in each of said paths simultaneously and in opposite senses.

6. An electrical voltage regulating device comprising, a pair of variable resistance elements, mechanical means effective to vary the resistance of said elements simultaneously and in the opposite sense, said mechanical means including a balanced armature of magnetic material, a frame having a polarized central leg of magnetic material and a pair of outer legs of magnetizable material positioned in operative relationship to said armature, said armature completing a pair of flux paths through said frame and armature including opposite ends of said armature, and a pair of exciting coils mounted on said frame for varying the magnetic flux in said paths simultaneously and in opposite senses, said coils being respectively oppositively wound thereby to induce a flux component in one of said paths additive to the flux component produced by said polarized leg while simultaneously therewith inducing a flux component in said other path subtractive from the flux component produced by said polarized leg.

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