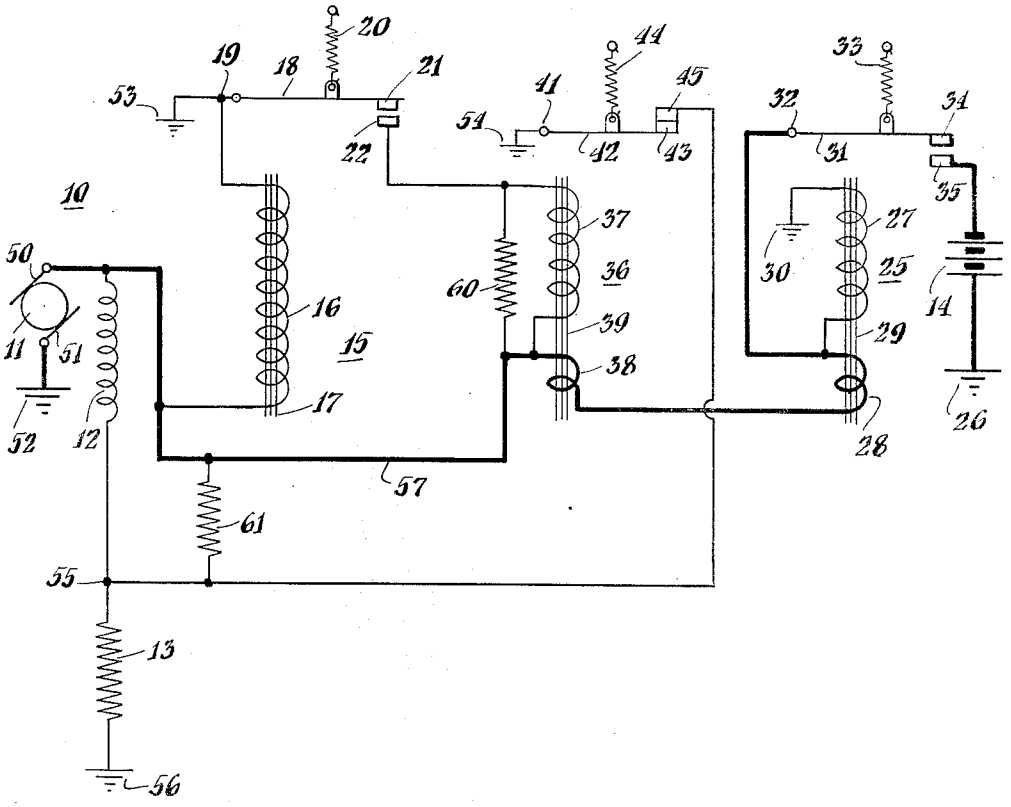
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VOLTAGE REGULATOR FOR BATTERY-CHARGING SYSTEM

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VOLTAGE REGULATOR FOR BATTERY-CHARGING SYSTEM

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1

This invention relates to an electrical generating system and, more particularly, to a combined voltage and current regulating system for electric generators associated with a storage battery or other loads.

Observation of present type automotive regulators has shown that in the operation thereof the regulator contacts operate at a point of extremely light contact pressure and very small deflections. This has resulted in erratic results since very slight transfer of material or oxidation may cause improper functioning of the regulator. This has also limited the amount of field current that could be successfully controlled to approximately two amperes. In addition, life tests on such regulators show that even with contacts of especially chosen materials, satisfactory performance of all contacts is not assured.

Therefore, a principal object of this invention is to solve the above mentioned problems.

Another object of this invention is to provide an electrical generating system in which both voltage and current control thereof is obtained within broad limits and satisfactorily held through a substantially high frequency vibratory relay system.

A further object is to provide a combined voltage and current responsive relay adapted to carry heavy field currents.

A still further object of this invention is to provide a voltage and current regulating system in which the high field currents thereof are carried by the heavier contacts.

Still another object is to reduce contact activity at the voltage sensitive element controlling contacts thereby increasing their life and reliability.

Other objects of the invention will be apparent from the following description and accompanying drawing taken in connection with the appended claims.

The invention accordingly comprises the features of construction, combination of elements, arrangement of parts, and methods of manufacture referred to above or which will be brought out and exemplified in the disclosure hereinafter set forth, including the illustrations in the drawing, the scope of the invention being indicated in the appended claims.

In accordance with my invention, the current regulating stage of the standard regulator for a generating system used in charging storage batteries is provided with a voltage coil and is made the so called power relay. This relay is made sufficiently fast to follow the pulses received

2

from voltage regulator or voltage sensitive element contacts. The voltage regulator element of the standard regulator is retained using the same magnetic structure and temperature compensated coil. The armature therefor is reduced in size and mass and is operated with a smaller magnetic air gap to increase its sensitivity.

The voltage regulator contacts close when the generator voltage exceeds a desired value thereby causing the power relay coil to be energized. Hence, the power relay contacts are opened reducing the field current and generator voltage which action, in turn, causes the voltage regulator contacts to reopen. This cycle is continuously repeated as long as the above condition exists. The combined sensitivity of the voltage regulator and the speed of the power relay provide sufficiently fast operation to give smooth and sensitive regulation over the working range.

Current regulation is not affected by the voltage coil since the instant the current regulation begins, the voltage regulator contacts open and the power relay voltage coil is not energized. The contacts of the power regulator are normally closed and the spring bias against a movable contact is adjusted with reference to the ampere turns of the current coil so that at a predetermined high current the unit functions as a normal current regulator. As a power relay, the voltage coil on this unit has sufficient ampere turns to actuate the armature when the voltage regulator contacts close.

Basically, the above system of voltage and current control for a battery charging system retains the inherent sensitivity of the known type regulator by using the voltage actuated relay whose armature functions to open and close contacts which operate the voltage coil of the auxiliary or power relay. By proper design of the power relay, the current drawn by its coils and, therefore, that required by the voltage regulator's or voltage sensitive relay's contacts is of the order of .1 to .2 ampere, which is below the value where silver or silver alloy type contacts tend to transfer or erode to any appreciable extent.

The power relay contacts are arranged to make and break the field currents. To accomplish this in a more reliable manner than conventional regulators requires that the power contacts substantially make and carry the field current at higher contact pressure and break or open the field circuit with a faster rate of separation than is possible with conventional regulator designs. These requirements call for a high speed type relay, since for larger contact motion, the faster

the armature must move to traverse this distance if the power relay keeps fully in step with the pulses received from the voltage regulator element. If the power relay does not keep in step with the voltage regulator contact pulses, then the system overshoots, resulting in larger generator current variations at slower intervals, causing objectionable fluctuation of the charge rate indicator or ammeter on the instrument panel.

I have found that sufficiently fast operation or pulse frequency can be obtained without too much difficulty by limiting the motion of the power relay contacts to approximately .010'' and reducing the armature mass of the power relay and increasing the sensitivity of the voltage sensitive element relay. Pulse rates of approximately 15 to 20 cycles per second under normal regulating conditions can be obtained, and the ammeter fluctuation does not exceed that normally obtained under same test conditions with conventional regulators.

In order to save the cost of a fourth or power relay element added to a conventional regulator, now employing a voltage regulator relay, a current limiting relay and a cut-out relay, I have found it entirely feasible to combine the functions of the power relay with that of the current limiting ralay without any interaction of their functions.

In the drawing:

The single figure of the drawing is a diagrammatical representation of the preferred embodiment of the present invention.

As illustrated in the drawing, a controllable source of power 10 which, in the present instance, comprises a shunt type generator having an armature 11 shunted by a field winding 12 biased or loaded by an impedance 13 of the resistance type preferably is utilized to transmit electrical energy to a load such as a battery 14 through a number of relays to be described in detail hereinafter. Coupled to the generator or controllable source of energy 10 there is found a voltage responsive relay 15 having a coil 16 wound on a core 17 adjacent to one end of which is a vibratory type armature 18 preferably of the high frequency type. In the drawing, the vibratory reed 18 arranged for bridging a pair of contacts 21 and 22 normally open is shown pivoted about a point 19 and biased by a spring 20 the latter being shown for the purpose of better illustrating the resilient property of the vibratory reed. Of course, the spring 20 may be eliminated and incorporated in the reed itself. The regulator 15, as stated heretofore, is one of the well known type and, therefore, need not be described in all details. The contacts 21, 22 normally held open and arranged to be bridged by the vibratory reed 18 are of substantially small mass to facilitate the desired high frequency movement of the reed.

A cut-out relay 25 is coupled to the battery 14 which is grounded at 26 in a conventional manner. The relay 25 includes the windings 27 and 28 preferably wound in a bifilar relationship on the core 29, both being grounded as at 30. These windings when energized motivate a vibratory reed or armature 31 preferably of the high frequency type which is pivotally mounted as at 32, the reed with a contact 34 being held in an open position with respect to a fixed contact 35 by the separate spring means 33 which may be, of course, incorporated into the reed 31, as is well known in the vibrator art.

A combined power relay and current regulator

36 is interposed between the voltage relay 15 and the cut-out relay 25. The relay 36 includes two coils 37 and 38 preferably wound in a bifilar relationship and in an additive magnetic sense upon the core 39 adjacent to one end of which is pivotally mounted at 41 a vibratory reed 42 having a contact 43 on one end thereof. The reed or armature 42 is resiliently retained in such position by the spring 44 that contact is normally made between the contact 43 and a fixed contact 45. The contacts 43 and 45, as contrasted with the others described above are of rather heavy construction to carry the heavy load currents of the generating system for a purpose to be more clearly described hereinafter.

Tracing the current flow from the armature 11 of the generator 10 through brushes 50 and 51, it will be seen that there are a plurality of circuits all being grounded at 52 from the brush 51. The electromagnetic winding 16 of the voltage responsive relay 15 is connected in parallel with the armature 11, the coil 16 of the relay being grounded at 53. Another circuit from the armature 11 starting from the brush 50 includes the field winding 12, normally closed contacts 43 and 45, reed arm 42 and the ground 54, the latter described circuit from the point 55 on one end of the field winding 12 producing a shunt or short circuit around the resistor 13 which is grounded at 56 and is in series with the field 12. Still another circuit from the brush 50 of the generator 10 comprises the conductor 57 adapted to carry heavy currents, the winding 38 of the dual coil relay 36, the current winding 28 and the voltage winding 27 of the cut-out relay 25 grounded at 30. The latter circuit is adapted to close the contacts 34 and 35 upon the voltage of the battery 14 and the voltage of the generator 10 having reached a predetermined relationship and functions in a well known manner. A further circuit originates at the brush 50 and includes a portion of the conductor 57, the voltage winding 37 of the power relay portion of the combined power and current relay 36, the fixed contact 22 and the movable contact 21 when the latter is forced into a downward or contacting position by the action of the energized electromagnetic winding 16 upon the vibratory reed 18 under the conditions previously described, the circuit being completed through the ground 53. The voltage winding 37 of the relay 36 is bridged by an impedance such as a resistor 60 for the purpose of absorbing the energy generated in the winding 37 upon the contact 21 and 22 being opened to thereby protect the contacting faces of the contacts. Additional means to avoid the effects of transients upon the various contacts of the above described relay and brush contacts 50 and 51 of the generator 10 comprises a load such as a resistance 61 across the field 12 of the generator 10. The invention also contemplates the use of a rectifier in shunt with the field 12, for the purpose of further suppressing the arcing tendency of the power relay contacts.

It has also been found that a dry disc rectifier such as of the magnesium copper sulphite type connected in shunt with the power relay element contacts 43 and 45 is very effective for higher field current arc suppression.

In the operation of the present battery charging system, the generator 10 is driven by any suitable driving means such as an automobile engine. When the speed of the generator reaches a value such that the output voltage is sufficient, the voltage applied to the electromagnet 25 is

sufficient to attract the armature and move that arm against the biasing force of the spring **33** to effect engagement of the contacts **34** and **35** and close the load circuit so that the voltage is applied to the load or battery **14** by the generator **10**. When the contacts **34** and **35** are closed the load current flowing through the generator to the load flows through the electromagnet winding **28** to hold or lock the arm **31** in the contact closed position so that variations in the generator voltage will not permit the release of the arm **31** and disengagement of the contacts **34** and **35** unless the generator voltage drops below a predetermined value. Assuming normal operation when neither output voltage nor output current are excessive the field winding **12** is directly grounded through the normally closed contacts **43** and **45** of the combined power and current relay **36**. When the voltage of the generating system reaches the desired value the voltage responsive relay **15** closes its contacts **21** and **22**. This action, in turn, energizes the winding **37** of the relay **36**, the circuit being from the "hot side" or brush **50** of the generator **10**, and including the winding **37** or relay **36**, closed contacts **21** and **22** of the voltage relay **15** and ground **53**. The relay **36** will open its contacts **43** and **45** and thereby interpose the resistance **13** which may be in the neighborhood of 30 ohms in series with the generator field winding **12**, thereby reducing the output voltage of the generator to a proper value. The value of resistance **13** being such that at maximum generator speed, a safe charging current is maintained. It will be noted from the above operation of a battery charging system that the contacts **21** and **22** do not carry the heavy field currents of the generator system but merely close a circuit through the winding **37** containing sufficient turns for operating a rather heavy contact **43** which does carry the field current of the generator.

When the load current to the battery **14** becomes excessive the current flowing in the circuit from the brush **50** of the generator through coil **38** of the relay **36**, the coil **28** of the cut-out relay **25**, closed contact **34** and **35** of the latter relay, battery to ground is sufficient to open the relay **36** to break its contacts **43** and **45**. This will likewise interpose the resistance **13** in series with the field winding **12** thereby maintaining the output current of the generator to a proper value.

The constants of the current regulator portion including the winding **38** of the relay **36** such as the normal ampere turns thereof and the normal tension of the spring **44** and also the value of the resistance **13** are preferably chosen so that under the normal operating conditions of the system the arm **42** vibrates and thus intermittently or periodically short circuits the resistance **13**. That is, when the electromagnetic force of the current coil **38** becomes sufficient it attracts the reed **42** to disengage the contacts **43** and **45**. This disengagement of the contacts **43** and **45** opens the short circuit across the resistance **13** to effect a reduction of the current in the shunt field winding **12**. This reduction of the exciting current sufficiently decreases the generator output current to reduce the magnetomotive force of the winding **38** to a value that permits the spring **44** to return the reed **42** to its normal closed position and effect engagement of the contacts **43** and **45**. When the contacts are thus reengaged, the field current to the exciting winding **12** is again increased. This operation preferably occurs and reoccurs in rapid succession under normal operating conditions and the speed or rate at which these operations reoccur is dependent upon the current output of the generator or load current. Thus, the current regulator including the parts **38, 39, 42—45** within the combined relay **36** tends to regulate so as to compensate for variations in generator speed and load on the generator. This regulator thus tends to maintain the generator current at a constant maximum safe value regardless of variations within reasonable limits of the generator speed or variations of load on the generator.

It will be evident from the above description that the reed **42** of the current limiting and power relay **36** is arranged to be responsive to the total output current of the generator **10** and the actuating pulses from the voltage coil **37** in series with the contacts **21** and **22** in the voltage responsive relay **16**. The voltage coil **37**, as mentioned heretofore, has sufficient ampere turns so that when the contacts **21** and **22** are closed it causes the armature **42** to rapidly open the contacts **45** and **43** in series with the generator field **12** regardless of the current level in the series current coil **38**. The relay **36** is adjusted to function as a normal current regulator by adjusting the armature or reed bias spring pressure versus magnetic attractive force of the current coil **38** to the desired maximum current value.

Summarizing the invention, it is recognized that I have provided a regulating system for a generating system particularly associated with battery charging in which the voltage responsive relay **15** is capable of high sensitivity and high speed operation but handles only low currents. This voltage sensitive relay **15** actuates the second or power relay **36** which is capable of handling heavy field currents since it is positively driven through a substantial displacement by means of winding **37**, the relay may have heavy contact pressures suitable for operating in the field coil circuit of the generator without any difficulty. Thus, I have provided a regulating system in which the requirements of obtaining sensitive, accurate and smooth regulation have been harmonized with the additional requirement of handling heavy field currents with reliable contact performance.

While the present invention, as to its objects and advantages, has been described herein as carried out in specific embodiments thereof, it is not desired to be limited thereby but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. An electrical generating system comprising a controllable source having a biasing impedance, a load, a cut-out coupled to said load when a predetermined voltage relationship between said source and the latter is attained, a voltage responsive regulator including normally open contacts coupled to said source, said regulator including a coil connected to one of said open contacts, said other contact being fixed, and a two coil regulator including a pair of normally closed contacts and being responsive to both voltage and current respectively said two coil regulator being interposed between said cut-out and said voltage regulator, one coil of said two coil regulator being connected to said fixed contact and thus to said source through said normally open contacts upon a predetermined voltage energizing said voltage responsive regulator, said normally closed contacts completing a circuit in

shunt with said biasing impedance whereby said source can be controlled in accordance with the position of said normally closed contacts, the other coil of said two coil regulator being adapted to carry load current whereby said regulator acts to limit the load current to a predetermined maximum value independent of said voltage responsive relay.

2. An electrical generating system comprising, in combination; a variable speed generator having a shunt exciting winding; a load; relay means for controlling the voltage and current of the generator, said means including a combined power relay and current regulator coupled to said load, a voltage responsive relay coupled to said combined relay and said generator field, said voltage responsive relay including an armature and a pair of normally open contacts, with said armature connected to one of said contacts, said power relay being connected to said other open contact and responsive to the operation of said voltage responsive relay upon the latter being impressed with predetermined voltages in accordance with changes of generator speed beyond a predetermined amount, and a resistor normally being shunted by said combined power and current regulator contacts.

3. In a storage battery charging system the combination comprising a shunt dynamo, a resistor in the shunt field circuit in series with the armature and field coil, a dual coil relay responsive to predetermined levels of both current and voltage and including a vibratory armature arranged with contacts intermittently closing a circuit shunting said resistor when said levels are reached, a voltage responsive relay interposed between said dynamo and dual relay and having an armature arranged with contacts intermittently closing a circuit coupled to the voltage responsive coil of said dual relay, one coil of said dual coil relay connected to one of said latter contacts, and a cut-out interposed between said dual coil relay and said battery for closing a circuit through the current responsive coil of said dual relay upon a predetermined voltage equal to the minimum level of said voltage levels being reached.

4. An electrical generating system comprising, in combination, a generator having a shunt field winding; a load; and means for controlling the voltage of the generator, said means including a resistance in series with said field winding and at least two relays each having a vibratable armature, one of said relays having a contact on said armature and also having a contact which is fixed, said relay being responsive to voltage changes about a predetermined level to cause a vibration of the armature thereof with an amplitude and frequency dependent on the magnitude of said voltage changes about said predetermined level, another of said relays including both voltage and current coils, said voltage coil of said latter relay being connected to said fixed contact of said voltage responsive relay, the voltage coil of said another relay being activated through the response of the armature of said one relay, the current coil of said another relay being coupled in series with said generator, the armature of said another relay in the unattracted position thereof forming a shunt path around said resistance whereby the voltage of said generator is lowered upon the energization either of said voltage coil of said another coil in response to said predetermined voltage changes in said one relay or of the current changes in said another coil alone, the said relays being so further arranged as to make said one relay inactive in effect upon said current coil alone motivating its associated armature.

5. A regulating system for an electrical battery charger including a generator of the shunt field type comprising a first voltage regulator including a coil coupled to the armature of said generator and responsive to voltage changes about a predetermined value, a second regulator including a voltage coil and a current coil coupled to said voltage regulator and responsive upon initiation of said voltage regulator, a cut-out relay including a voltage coil and current coil coupled to the current coil of said second relay and interposed between the latter and said battery, and an impedance coupled to said shunt field in series therewith upon the initiation of said second regulator, to thereby lower the voltage output of said generator, said cut-out relay when activated providing a current path through the current coil of said second regulator, said second regulator being responsive to current changes above a predetermined value to thereby place said impedance again in series with said field, said impedance and said voltage regulator coil being parallel to each other when the voltage regulator becomes unresponsive during the time said second relay is motivated by said current changes.

6. An electrical generating system comprising a variable speed generator having an armature and a shunt field winding, a load, voltage responsive means including a set of contacts, one of which is fixed to an armature movable in response to voltage changes at said generator about a predetermined value and the other of which is always fixed, a cut-out coupled to said load, regulator means interposed between said cut-out and said voltage responsive means and adapted for handling heavy current, said regulator means including a voltage coil directly connected to said always fixed contact and in series with said set of contacts upon said predetermined value of generator voltage being reached whereby said regulator means is dependent upon said voltage responsive means in producting voltage regulation, said regulating means also including a current coil in series with said cut-out and said armature whereby current regulation is produced without said voltage responsive means, and a resistor normally in series with said generator field, said resistor being shunted by said regulator means during said voltage and current regulating periods.

7. A regulating system for a battery charger of the generator type having a shunt field, comprising a first relay including a coil in shunt with said field and a vibratable armature for bridging a set of contacts, one of said contacts being fixed and the other on said armature, the frequency of said armature being proportional to the voltage output of said generator versus the battery voltage; a second relay including both voltage responsive and current responsive coils, the voltage coil thereof being connected in parallel with the coil of said first relay through said set of contacts, said voltage coil being connected to said fixed contact, said second relay including a vibratable armature for bridging a set of contacts normally closed when the generator voltage is below a predetermined value; a resistor in series with said shunt field when said normally closed contacts are opened; and a third relay including both voltage and current coils and an armature carrying a contact for engagement with a fixed contact of said relay, said third relay functioning as a cut-

out interposed between said battery and said second relay, the current coils of said second and third relays being in series whereby said first relay so assists in the control of the battery charger that only the set of contacts in the second relay are subjected to heavy field current.

8. In an electrical generating system wherein a storage battery is charged by a shunt-armature type generator through a cut-out device, the subcombination comprising a vibratory reed type voltage regulator with a voltage coil, said regulator including a contact on said reed and a fixed contact, a combined voltage and current responsive regulator of the vibratory reed type with two coils coupled additively, one of said two coils being directly connected to said fixed contact and to the reed of said voltage regulator upon the latter being impressed with a predetermined minimum voltage, the other of said two coils being coupled to said armature in series therewith whereby said combined regulator is made responsive to current beyond a predetermined maximum value independent of said voltage regulator, and field current limiting means coupled to the field of said shunt generator, said field current limiting means being shunted by the vibratory reed of said combined regulator when either the voltage across the battery or the current through the generator is lower than a predetermined value.

9. In an electrical generating system wherein a shunt wound generator having a substantially high current carrying capacity armature is used to charge storage batteries protected by a cut-out and a voltage regulator of the vibratory reed type

having relatively light contacts normally open when the voltage on said regulator is below a predetermined amount, one of said contacts being on said reed and the other fixed, the subcombination comprising a two-coil-single-core wound regulator including a vibratory reed arranged for intermittently connecting contacts adapted to carry substantial current and being interposed between said cut-out and voltage regulator, one of said latter coils being connected to said fixed contact of said voltage regulator with said intermittent contacting being dependent either on a closed position of said normally open position of the contacts of said voltage regulator to effect voltage regulation or on a predetermined current density through one of said two coils independent of said voltage regulator.

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