

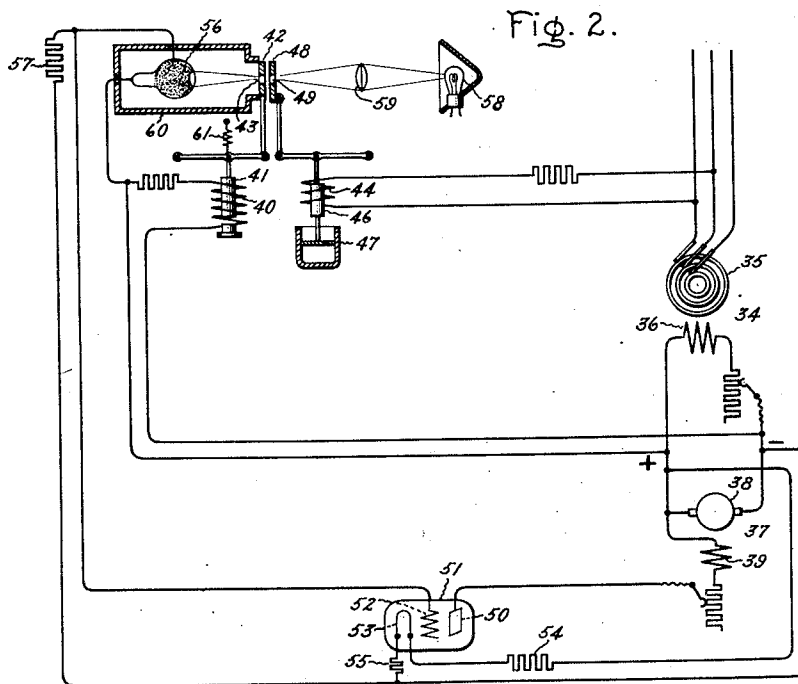
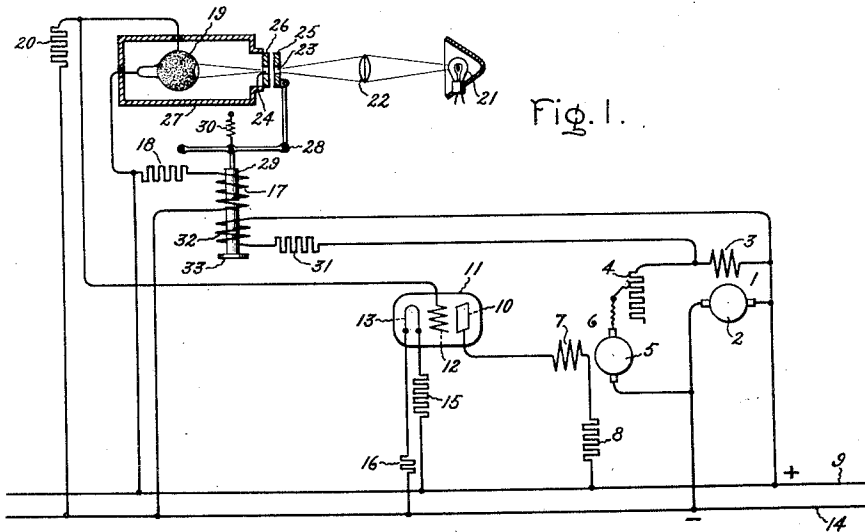
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REGULATOR

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UNITED STATES PATENT OFFICE

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REGULATOR

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My invention relates to regulators and particularly to vibratory type regulators employing a light sensitive means for controlling an operating condition of electrical apparatus.

Vibratory type regulators, as exemplified by the well-known Tirrill regulator, although very successful in operation, have heretofore depended on the rapid engagement and disengagement of a pair of contacts. They have therefore been occasionally subject to some of the disadvantages and shortcomings which such a mode of operation entails in machines embodying it, such as arcing, pitting of the contacts, contact wear, and sticking of the contacts.

It is an object of my invention to provide a vibratory type regulator in which vibratory contacts are eliminated.

It is another object of my invention to provide a new and improved regulator and regulating system employing light sensitive means of the vibratory type.

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

Referring now to the drawing, Fig. 1 is a diagrammatic illustration of a regulator, for a direct current machine, embodying my invention, while Fig. 2 is a like illustration of a regulator, for an alternating current machine, which embodies my invention.

While the illustrated embodiments of my invention will be described with reference to voltage regulation, it will be obvious to those skilled in the art that it may embody any regulators or regulating systems operating on a similar principle for regulating current, power, power factor, speed, etc., without departing from my invention in its broadest aspects.

In Fig. 1, 1 is a direct current shunt generator having an armature 2 and a field winding 3, whose circuit contains a variable field rheostat 4 and the armature 5 of a counter E. M. F. generator 6. The field winding 7 of generator 6 is connected in series with resistance 8 between the positive terminal of

generator 2, by means of conductor 9, and the plate 10 of an electric discharge device 11. This discharge device, which I employ merely as an amplifier, is of the three element type, its other two elements being a grid 12 and a filament 13, the latter being energized from conductors 9 and 14, which are connected to the terminals of generator 1, through properly proportioned resistances 15 and 16. Also connected across the terminals of generator 1, through conductors 9 and 14, is a main control coil 17, in series with a current limiting resistance 18. For controlling an electrical condition of the generator 1, I provide a light responsive device shown as a photoelectric cell 19, which is connected across generator 1 in series with a resistance 20. By light I wish to be understood to include radiations falling outside the range of the visible spectrum as well as those which are visible. The grid of the discharge device is connected to the positive side of resistance 20. Co-operating with light-responsive device 19 is a light source 21 and lens system 22 for bringing the light from source 21 to a focus so that it may be passed through apertures 23 and 24 in shutters 25 and 26 respectively and on to the light sensitive device 19. Shutter 26 forms a part of an otherwise light impervious container 27 for cell 19, while shutter 25 is connected through a pivoted system of levers 28 to a core 29 in coil 17. Spring 30 opposes the pull of coil 17 on core 29. Connected in series with resistance 31 across field 3 of generator 1 is a coil 32, hereinafter referred to as the vibrating coil. This coil is mounted in axial alignment with coil 17. Core 33 is adjustable and is provided to adjust the magnetic pull on core 29.

The operation of the embodiment shown in Fig. 1 is as follows. Assume that generator 1 is being driven at its normal operating speed by any suitable means and that machine 6 is in operation. Filament 13 will be energized, and due to resistance 16 will be at a potential greater than that of the negative conductor 14 by the voltage drop in said resistance. If no light falls on cell 19, it is non-conducting to all practical intents and purposes. Therefore, no current passes through

resistance 20 and grid 12 which is connected therethrough to the negative conductor 14 is negatively biased with respect to the filament. The result is that a minimum of current flows in the plate circuit of amplifying device 11, which results in a minimum current flowing in field 7 of counter E. M. F. generator 6. Hence the voltage of this machine is a minimum, so that the voltage across field 3 of the regulated machine 1 is a maximum. Therefore, the current in field 3, which tends to lag the voltage across it because of the considerable inductive reactance of the field, will be at a maximum a short time thereafter, unless the voltage across the field is decreased soon enough. An increase in field current of course tends to increase the voltage of generator 1, other things being the same. If now, light is permitted to fall on cell 19, current flows therethrough, producing a voltage drop in resistance 20, which has the effect of raising the potential of grid 12, thereby reducing its negative bias with respect to the filament which in turn results in an increase in plate current and hence an increase in current through field 7 of counter E. M. F. machine 6. The result is that the voltage of machine 6 increases, thereby decreasing the voltage across field 3 of regulated machine 1 so that unless this decrease in voltage is checked, the current in field 3 will decrease, causing an attendant decrease in generated voltage at the terminals of machine 1. Summarizing the above, it is therefore clear that when light falls on cell 19, the voltage across field 3 decreases, thereby tending to decrease the voltage at the terminals of machine 1, while when light does not fall on cell 19 the reverse effect is had on the voltage across field 3 and therefore on the terminal voltage of machine 1. If then, the relative pulls of coil 17 and spring 30 on core 29 are so adjusted that when the terminal voltage of machine 1 exceeds normal, the core 29 is pulled down, causing the openings 24 and 25 to register and allow light to fall on cell 19, while when the voltage of machine 1 falls below normal, the pull of coil 17 is overpowered by the pull of spring 30 and shutter 25 rises, thereby cutting off the light to cell 19, the voltage of machine 1 will be automatically regulated, for any increase in voltage causes such a regulation of the light supply to the cell as to produce a weakening of current in field 3, while a decrease in voltage causes the opposite effect. If now conditions, such as generator speed or load, should change a different average field current or excitation will be necessary in order to maintain normal generator voltage. This will simply mean that the openings 23 and 24 will be either in or out of registration for a greater or less proportion of a given time, thereby causing a decrease or increase respectively in the average field current of machine 1. While the above de-

scribed regulation is perfectly feasible it may produce considerable periodic variations in generator voltage otherwise known as hunting, because due to the time lag between voltage and current changes for field 3 the current therein will over-shoot or under-shoot the value necessary to return the generator voltage to normal before the correcting voltage which is applied to it can complete its effect. To overcome this difficulty, should it be present, coil 32, which is designed to cumulate its effect with respect to coil 17 is connected across field 3 and is provided with an adjustable core 33. Thus, as core 29 descends, resulting in light falling on cell 19 and causing a decreased voltage across field 3, the effect of coil 32 decreases so that core 29 rises, thereby causing the light to be shut off from cell 19. As soon as the light is shut off the voltage across field 3 rises thereby causing coil 32 to increase its pull. The result is that when the external conditions affecting the terminal voltage of generator 1, such as its speed or load, are constant, the movement of core 29 will be exceedingly small and exceedingly rapid and will be governed almost entirely by coil 32 which is holding practically a constant voltage on field 3. In other words, small aperture 23 will be practically operating on the upper edge of aperture 24. When now some external condition governing the terminal voltage of machine 1 changes, coil 17, whose effect is stronger than that of coil 32, will either hold apertures 23 and 24 in registration or keep them out of registration, depending upon the direction in which the voltage changed, until the voltage is caused to swing in the opposite direction and back to normal, when vibrating coil 32 will come into play again. To put it another way, when the voltage of generator 1 tends to change, coil 17 arrests the vibration of core 29 until a new point is reached on the saturation curve of counter E. M. F. machine 6 which will produce the necessary correction, and then coil 32 will operate to hold this excitation.

Fig. 2 differs from Fig. 1 in that the regulation is applied to an alternator 34, comprising armature 35 and field winding 36, instead of to a direct current machine. Also in that an exciter 37, comprising an armature 38 and field winding 39 is used for varying the excitation of the regulated machine, whereas in Fig. 1 a counter E. M. F. machine is used. The figures differ further in that the vibrating coil 40, which is connected across exciter 38, is provided with a separate core 41, connected by suitable linkages to a movable shutter 42, provided with aperture 43, while main control coil 44, which is connected across the alternator terminals, has its core 46 provided with a dash pot 47. Core 46 is connected by suitable linkages to a movable shutter 48 provided with aperture 49. 130

Elements 50-60 inclusive of Fig. 2 correspond respectively to elements 10-13 inclusive, 15, 16, 19-22 inclusive and 27 of Fig. 1, the filament 53 of discharge device 51, however, being connected across exciter 37, with the smaller of the two resistances 54 and 55, which is 55, in the line leading to the negative side of exciter 37.

The operation of the embodiment shown in Fig. 2 is as follows. When openings 43 and 49 are in registration, light from source 58 which has been focussed by lens system 59 at these apertures, passes therethrough and falls on cell 56, thereby rendering it conducting, thereby removing the bias from grid 52 and allowing current to flow through the shunt field 39 of exciter 37, thereby increasing the voltage of alternator 34. If now there are no external conditions tending to produce a change in the alternator voltage, core 46 and shutter 48 will remain stationary, spring 61 will overpower the pull of coil 40, thereby permitting light to fall on cell 56, whereby the voltage of exciter 38 will increase; but before the current in field 36 has increased appreciably, this increase in exciter voltage will cause coil 40 to increase its pull and overpower the pull of spring 61, hence core 41 and shutter 42 will descend, cutting off the light to cell 56 and again decreasing the exciter voltage. The above-mentioned action is so rapid that its effect is to hold practically constant alternator excitation and voltage. If now the alternator voltage should change as the result of a change in load for example, the pull of coil 44 on core 46 will change allowing core 46 to rise or fall, depending upon whether the change in voltage was an increase or a decrease. Such motion of core 46 produces a corresponding motion of shutter 48, and is damped by dashpot 47. Whichever way shutter 48 moves, shutter 42 will follow it, for its vibratory action depends upon the intermittent cutting off and admitting of light to cell 56. Shutter 42 follows along after shutter 48, the alternator voltage being brought back to normal. For example, if shutter 48 is rising it means that the alternator voltage has increased, but as this rise has cut off the light to cell 56, the exciter voltage has dropped and spring 61 has overpowered the pull of coil 40. Both shutters will therefore continue to rise, or more accurately shutter 48 will rise steadily, while 42 will continue its vibratory motion, although its mean position rises until the mean exciter voltage returns to normal, when shutter 48 will stop, for coil 44 and core 46 are so designed that core 46 has a considerable range of displacement where its weight and downward forces upon it just balance the pull of coil 44 at normal voltage. Vibrating coil 40 will then cause core 41 and shutter 42 to continue their vibratory action.

While I have shown two particular vi-

bratory means for securing a rapid pulsation of the light admitted to the light sensitive element, it will of course be obvious to those skilled in the art that many other equivalent means for producing the same result may be employed, for example, the light source itself might be vibrated or the light source might be an incandescent lamp which is energized with a low frequency current so as to produce a flicker, in fact, any means for superimposing rapid pulsations in the amount of light admitted to said light sensitive device on the comparatively slow periodic variations in the amount of said light, which latter are caused by the movement of the means responsive to the conditions to be regulated, might be employed without departing from my invention in its broader aspects.

The above-described regulators permit of very close regulation and a minimum amplitude of vibration of the anti-hunting elements because a very sharp cut off of the light is possible with but an infinitesimal relative movement of the shutters. Furthermore, the apertures in the relatively movable shutters may readily be so shaped as to have many different kinds of relative position-area characteristics; that is to say, the effective area of the aperture may be any desired function of the relative position of the shutters, whereas to arrange a circuit wherein the current is any desired function of the relative position of a pair of movable contacts in the circuit is not so easily accomplished.

While I have shown and described particular embodiments 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 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. In an electrical regulator, a source of light, means including a light responsive element for altering the magnitude of a condition to be regulated, vibratory means for varying the amount of light admitted to said light responsive element, and means operative in accordance with the condition to be regulated for varying the average amount of light admitted to said light responsive element.

2. In an electrical regulator, a light sensitive device, a source of light, relatively movable shutters between said light source and said light sensitive device, means for moving said shutters relatively to each other in accordance with a condition to be regulated, and means for rapidly vibrating said shutters relative to each other.

3. In an electrical regulator, a source of

light, means including a light responsive element for varying the magnitude of the condition to be regulated, and vibrating means responsive to said variations for altering the amount of light admitted to said light responsive element in such a way as to oppose the change in magnitude of the condition to be regulated.

4. In combination, an electric circuit, means for controlling an electrical condition of said circuit, means including a source of light and a light sensitive device for controlling said first mentioned means, means operative in accordance with variations in said electrical condition for controlling said light sensitive device, and means for vibrating said last mentioned means.

5. In combination, an electric circuit, means for controlling an electrical condition of said circuit, means including a source of light and a light sensitive device for controlling said first mentioned means, means producing rapid pulsations in the amount of light admitted to said light sensitive element, and means operative in accordance with the condition to be regulated for varying the average amount of light admitted to said light sensitive element.

6. In combination, a dynamo electric machine, means for controlling an operating condition of said machine, means including a source of light and a light sensitive device for controlling said first mentioned means, means operative in accordance with variations in said operating condition for controlling the light sensitive device, and means for vibrating said last mentioned means.

7. In combination, a dynamo electric machine, means for controlling an operating condition of said machine, means including a source of light and a light sensitive device for controlling said first mentioned means, means for producing rapid pulsations in the amount of light admitted to said light sensitive element, and means operative in accordance with the condition to be regulated for varying the average amount of light admitted to said light responsive element.

8. In combination, a dynamo-electric machine, a regulator therefor including a source of light and a light sensitive device for controlling an electrical characteristic of said dynamo-electric machine, and vibrating means operative in accordance with variations in said electrical characteristic for altering the amount of light admitted to said light sensitive device in such a way as to oppose a change in said electrical characteristic.

9. In a regulating system, a dynamo-electric machine, a light sensitive cell, a source of light, a pair of relatively movable shutters between said light source and cell, means for moving said shutters relative to each other in accordance with an electrical characteristic of said dynamo-electric machine so as to vary

the light admitted to said cell in proportion to the variation in said electrical characteristic, means for vibrating one of said shutters, and means controlled by said cell for controlling said electrical characteristic of the dynamo-electric machine.

10. In a regulating system, a dynamo-electric machine, a light sensitive cell, a source of light, a pair of relatively movable shutters between said light source and said cell, means for moving said shutters relative to each other in accordance with an electrical condition of said dynamo-electric machine so as to vary the light admitted to said cell in proportion to the variations in said electrical condition, means for vibrating one of said shutters in accordance with variations in an electrical condition of the field circuit of said dynamo-electric machine, and means controlled by said cell for controlling said electrical condition of the dynamo-electric machine.

11. In a regulating system, a dynamo-electric machine, a field winding for said machine, a light sensitive cell, a source of light, a pair of relatively movable shutters between said light source and said cell, means responsive to the voltage of said dynamo-electric machine for causing a relative movement between said shutters so as to vary the light admitted to said cell in proportion to the variation in said voltage, means responsive to the voltage of the field winding of said dynamo-electric machine for vibrating one of said shutters, and means controlled by said cell for controlling the excitation of said machine.

12. In a regulating system, a dynamo-electric machine, a regulator for controlling an electrical characteristic of said machine, said regulator comprising a light sensitive element and an amplifying means, means connecting the input circuit of said amplifying means to the circuit of said light sensitive element, means under the control of the output circuit of said amplifying means for varying the excitation of said dynamo-electric machine, and vibratory means responsive to changes in the regulated characteristic of said machine for varying the supply of light to said light responsive element in such a way that the regulating change in excitation of said machine opposes the change in said electrical characteristic.

13. In combination, a dynamo-electric machine, means for varying the excitation of said machine, a regulator including a photo-electric cell for controlling said excitation varying means, a source of direct current, means connecting the anode of said cell to the positive side of said source, means including a resistance connecting the cathode of said cell to the negative side of said source, amplifying means of the space discharge type, means connecting the grid of said

amplifying means to the positive side of said resistance, means connecting the filament of said amplifying means across said source, said means containing a resistance between said filament and the negative side of said source, means connecting said excitation varying means in the output circuit of said amplifying means, and means responsive to the voltage of said machine for varying the amount of light admitted to said cell in such a manner as to maintain the voltage of said machine substantially constant.

In witness whereof, I have hereunto set my hand this 15th day of November, 1929.

FRANK A. BYLES.