Dec. 16, 1941. R. H. KAUFMANN 2,266,607

REGULATING SYSTEM

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Fig. 1.

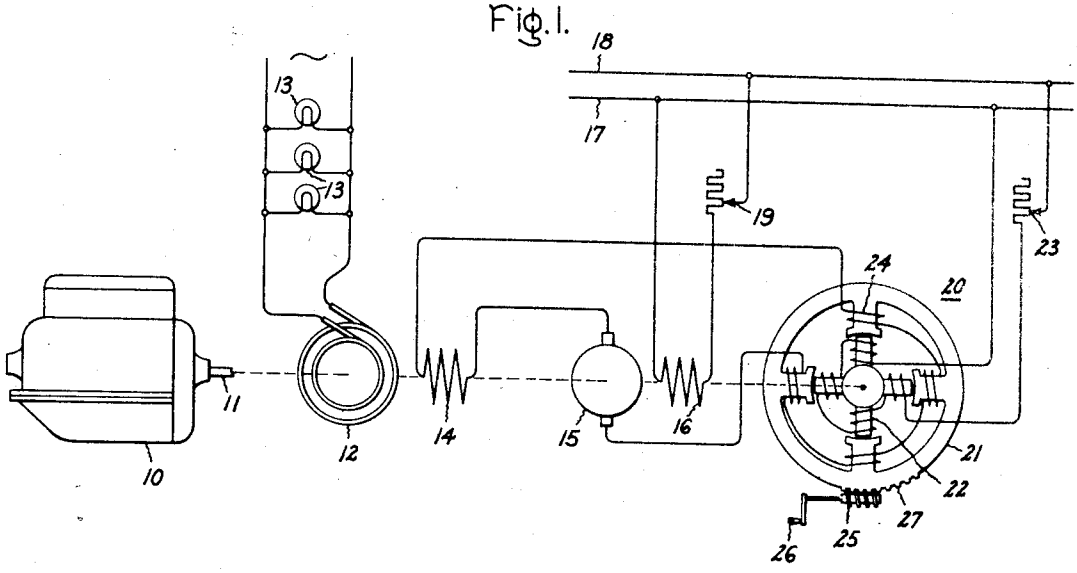
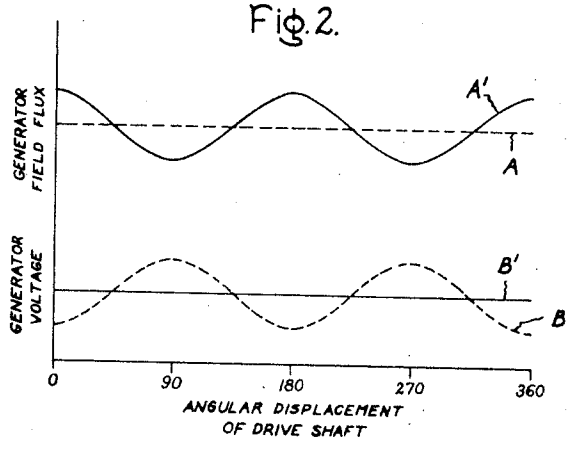


Fig. 2.



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REGULATING SYSTEM

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8 Claims. (Cl. 290—7)

My invention relates to electric regulating systems for electrical generating means of the type in which a generator is driven by an engine having a pulsating torque, and more particularly to means for reducing or eliminating pulsations in the output voltage of a generator caused by the characteristic pulsating torque delivered by an internal combustion engine.

All internal combustion engines of the conventional type deliver a pulsating torque which produces corresponding irregular characteristics in the electrical output of a generator connected to such an engine. In a case where the generator is supplying a lighting load the resulting flickering of the lights is often a source of great annoyance. In order to overcome this difficulty it is common to provide the internal combustion engine with a heavy flywheel which tends to smooth out the speed variations of the rotating system arising from the pulsating nature of the torque delivered by the engine. In many installations, however, the use of a heavy flywheel necessitates modifications of the foundation of the building structure in which the generating unit is enclosed, the cost of which is very high. In addition, the flywheel itself is often expensive and difficult to install and after it is installed it must be balanced very carefully to prevent vibration troubles.

It is an object of my invention to provide an electrical generating system having improved means for reducing or eliminating irregularities in the generator output voltage due to a pulsating torque occurring in the generator driving means.

Another object of my invention is to provide improved means for reducing or eliminating light flicker in lighting systems where the generator is driven by an engine delivering a pulsating torque.

It is a further object of my invention to provide a novel and improved light flicker compensating means that is inexpensive, simple and efficient in operation.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

Briefly, in accordance with my invention, I eliminate light flicker producing voltage pulsations in the output of an internal combustion engine driven generator by connecting a source of compensating alternating potential in series with a generator field winding. By selecting the proper frequency, phase and magnitude of the compensating alternating potential the field flux of the generator is caused to pulsate in a manner to compensate for the periodic speed variations of the generator due to the pulsating torque of the internal combustion engine whereby voltage pulsations and the accompanying light flicker are eliminated.

My invention will be better understood from the following description taken in connection with the accompanying drawing in which Fig. 1 illustrates in diagrammatic form one embodiment of my invention, and Fig. 2 shows certain graphic representations which are useful in explaining the theory of operation of my invention.

For the purpose of illustrating a specific embodiment of my invention I have illustrated in Fig. 1 of the drawing an internal combustion engine 10 connected by means of a drive shaft 11 to a dynamo-electric generator in the form of an alternator 12 which supplies power to an electrical lighting load indicated by the lamps 13. The alternator 12 has a field winding 14 which is supplied with unidirectional current from any suitable source such as a direct connected exciter 15. The exciter 15 has a field winding 16 connected to unidirectional current supply conductors 17 and 18. If desired, the exciter 15 may be self excited, in which case the field winding 16 would be connected across the terminals of the exciter. Connected in series with the exciter field winding 16 is an adjustable field rheostat 19 which is provided for the purpose of varying the generator excitation and terminal voltage. In the usual situation the field resistor 19 would be controlled automatically by a regulator responsive to the generator terminal voltage for the purpose of holding the terminal voltage constant but for the purpose of simplicity this has been omitted since it forms no part of the present invention.

Connected to the drive shaft 11 is an alternator indicated generally at 20 having an armature or stator 21 and a rotary field or rotor 22. The alternator field winding 22 is connected to the supply conductors 17 and 18 through a variable field rheostat 23. The armature winding 24 of the alternator 20 is connected in series with the armature of the exciter 15 so that an alternating potential is superimposed upon the unidirectional potential produced by the exciter 15 for a purpose which will be described below. The armature 21 of the alternator 20 is mounted so that it can be rotated relative to the drive shaft 11 to

vary the phase of the alternating potential produced thereby. To enable the phase of the alternator to be adjusted manually the armature 21 has a gear 27 connected thereto which cooperates with a rotatable worm gear 25. A hand crank 26 is connected to the gear 25 so that by rotation of the crank in one direction to the other the armature may be rotated to adjust the phase of the alternator voltage.

It is believed that the operation of my invention may be best explained by taking a concrete example for the purpose of illustration. Let it be assumed that the internal combustion engine 10 is of the four cylinder four cycle type so that it has two power strokes per revolution of the shaft 11. Due to the pulsating torque developed by the engine 10 the shaft 11 and the direct connected alternator 12 will have a periodic speed variation of two cycles for each revolution of the shaft.

Now let it be assumed for the moment that the alternator 20 is omitted and the armature of the exciter 15 is connected directly to the alternator field winding 14 so that the current in the field winding 14 and hence the field flux will remain substantially constant. Referring to Fig. 2 of the drawing, the dotted curve A represents the variation of the generator field flux 14 with time, the unit of time being measured in terms of angular displacement of the drive shaft 11. The dotted curve A is a straight line, since under the conditions assumed the field current of the field winding 14 is constant. For the condition of constant generator field current and flux the dotted curve B represents the variation in the terminal voltage of the generator 12 with angular displacement of the drive shaft. It will be noted from the curve B that the voltage of generator 12 pulsates with a frequency of two cycles per revolution of the shaft 11, this being caused by the periodic speed variations of the shaft of the same frequency. It is assumed for the purposes of illustration that the crank angles of the engine 10 are at ninety and two hundred sevently degrees for maximum speed of the shaft 11. The pulsations of the voltage of the generator 12 would ordinarily cause the lamps 13 to flicker and it is the purpose of my invention to eliminate these pulsations of voltage.

Now let it be assumed that the alternator 20 is connected in series with the exciter 15 as illustrated so that the alternating potential produced thereby is superimposed upon the unidirectional potential produced by the exciter. This causes the field current in the field winding 14 and hence the field flux of the generator 12 to pulsate as indicated by the curve A'. The pulsation frequency of the generator field flux will of course be determined by the frequency of the alternator 20. The alternator 20 is arranged to produce a frequency corresponding to the frequency of the torque pulsations of engine 10 and the resulting speed variations of the drive shaft 11 which in turn corresponds to the voltage pulsations of the generator 12 indicated by the curve B. Therefore, for the specific case cited, the alternator 20 should have a frequency of two cycles for each revolution of the shaft 11. This may be accomplished, for example, by providing the alternator with four field poles as illustrated and connecting the rotor directly to the shaft 11. If desired, however, the alternator 20 could be driven from a counter shaft at a speed proportional to the shaft 11 and have a different number of poles, the only requirement being that the frequency of the alternator correspond to the frequency of the speed variations of the shaft 11.

According to my invention the phase of the pulsations of the generator field flux 14 is adjusted so that the field flux is a minimum at a point in the rotation of the shaft 11 corresponding to maximum speed and is at a maximum value at a point corresponding to minimum speed. This phase shifting is accomplished by varying the angular position of the armature 21 of the alternator 20, this being done by rotating the hand crank 26. The magnitude of the field flux pulsations is varied by varying the excitation of the alternator 20 which may be done by adjusting the field rheostat 23. By properly adjusting the phase and the magnitude of the alternating potential produced by the alternator 20 the pulsations and the output voltage of the generator 12 can be eliminated so that a substantially constant voltage is obtained as indicated by the curve B'. My invention utilizes the principle that the voltage of the generator 12 is proportional to the product of the generator field flux and the speed. Thus by varying the field flux of the generator 12 inversely as the speed of the shaft 11 the product of the generator speed and flux and consequently the voltage is maintained constant. Hence light flicker due to voltage pulsations of generator 11 is eliminated.

In cases where the generator excitation is supplied by a direct connected exciter as in the illustrated arrangement, the periodic speed variations of the drive shaft will also tend to cause pulsations in the exciter voltage output. These pulsations, however, are small as compared to the magnitude of the alternating voltage produced by the alternator 20 and therefore they produce no appreciable effect on the generator field current and flux. For this reason they have not been considered in the foregoing description of operation.

The magnitude of the alternating voltage produced by the alternator 20 for complete compensation will vary somewhat with the load on the generator 12. However, in most instances the phase and the magnitude of the alternating voltage produced by the alternator 20 may be adjusted initially and left unchanged without resulting in sufficient voltage variation to produce flicker of the lamps 13 at any point between no load and full load. However, if desired, the field winding 22 of the alternator 20 may be energized directly from the armature terminals of the exciter 15 in which case the magnitude of the alternator voltage will be varied automatically with changes in load on the generator 12.

It is to be understood that although I have illustrated my invention in connection with a generator driven by an internal combustion engine, it is equally applicable to any generating system where the driving means has a periodic speed variation bearing a fixed relation to the angular displacement. Also it is immaterial whether the generator 12 is of the direct current or alternating current type.

While I have shown and described particular embodiments of my invention, it will occur to those skilled in the art that various 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 combination, an internal combustion engine, a dynamo-electric generator connected to be driven thereby, a field winding for said generator, an energizing circuit for said field winding connected to a source of unidirectional potential, an alternator connected in series with said energizing circuit, and means for driving said alternator from said internal combustion engine, said alternator having a number of poles so that it will produce an alternating potential having a frequency corresponding to the frequency of the torque pulsations of said internal combustion engine.

2. In combination, a dynamo-electric generator having a field winding, a drive shaft connected to said generator, said drive shaft having periodic speed variations, an energizing circuit for said field winding connected to a source of unidirectional potential, an alternator connected in series with said energizing circuit, and means for driving said alternator from said drive shaft.

3. In combination, a dynamo-electric generator having a field winding, a drive shaft connected to said generator, said drive shaft having periodic speed variations, an energizing circuit for said field winding connected to a source of unidirectional potential, an alternator connected in series with said energizing circuit said alternator having a rotor and a stator, means for driving said rotor from said drive shaft, and means for moving said stator relative to said rotor for adjusting the phase of the alternating potential produced by said alternator.

4. In combination, a dynamo-electric generator having a field winding, driving means connected to said generator, said driving means having periodic speed variations, an energizing circuit for said field winding connected to a source of unidirectional potential, and means for interposing in series with said energizing circuit an alternating potential having a frequency corresponding to the frequency of the speed variations of said driving means.

5. In combination, a dynamo-electric generator, driving means connected to said generator, said driving means having periodic variations in speed, and means for producing a pulsating field flux in said generator having the same periodicity as the variations in speed of said driving means.

6. In combination, a dynamo-electric generator having a field winding, driving means connected to said generator, said driving means having periodic speed variations, means for producing a field flux in said generator, and means for causing said field flux to pulsate at a frequency corresponding to the frequency of the speed variations of said driving means.

7. In combination, a dynamo-electric generator, driving means connected to said generator, said driving means having periodic speed variations, means for producing a field flux in said generator, means for causing said field flux to pulsate at a frequency corresponding to the frequency of the speed variations of said driving means, and means for adjusting the phase of said field flux pulsations relative to said speed variations.

8. In combination, a dynamo-electric generator, driving means connected to said generator, said driving means having a periodic speed variation bearing a fixed relation with its angular displacement, means for producing field flux in said generator, and means responsive to the angular displacement of said driving means for varying said field flux in accordance with the speed variation.

RICHARD H. KAUFMANN.