Jan. 19, 1937. S. F. FARKAS 2,068,316

ALTERNATING CURRENT REGULATOR

Filed Feb. 19, 1936

FIG. 1

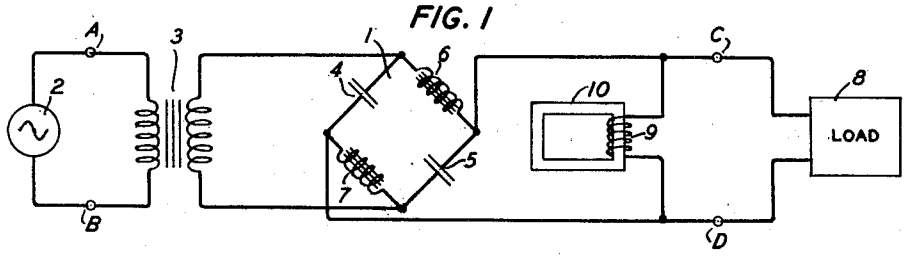


FIG. 3

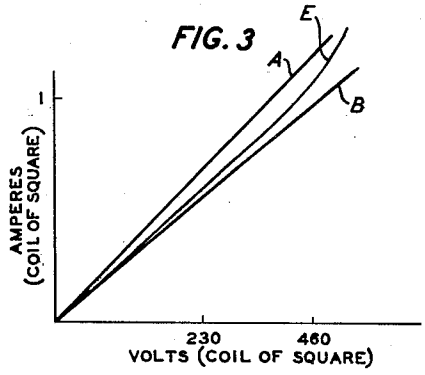


FIG. 2

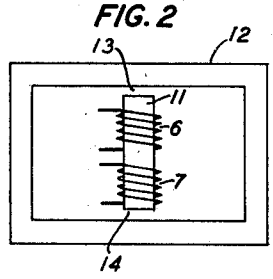
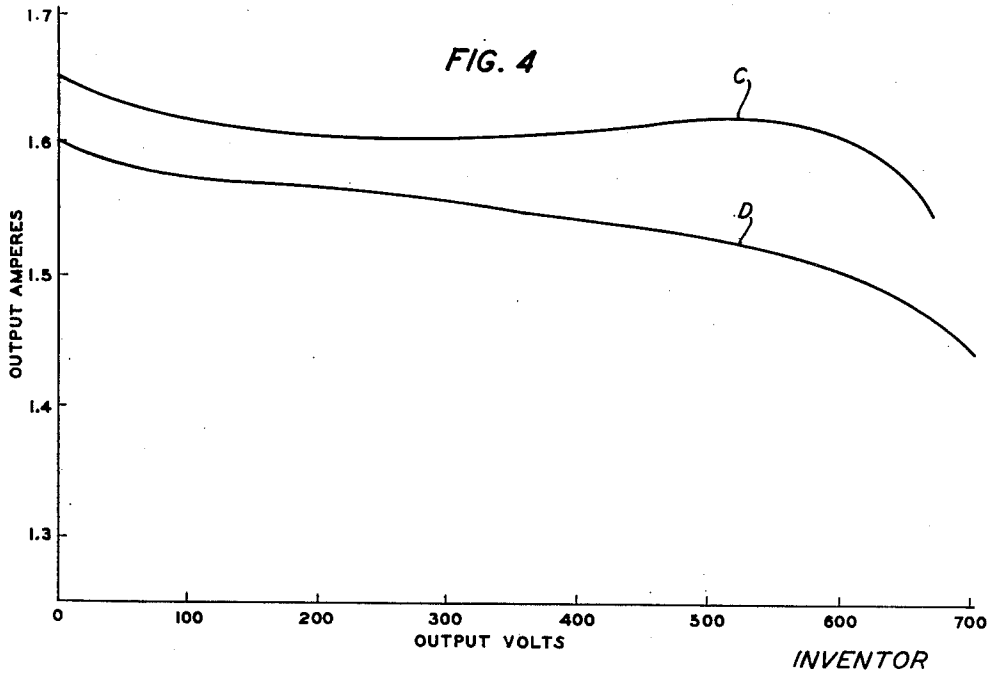


FIG. 4



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ALTERNATING CURRENT REGULATOR

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Application February 19, 1936, Serial No. 64,700

5 Claims. (Cl. 171—119)

This invention relates to regulators for alternating current systems and particularly to regulators for supplying alternating current at constant levels.

One object of the invention is to provide a monocyclic square regulator that shall be unbalanced varying amounts according to the load.

Another object of the invention is to provide a monocyclic square regulator that shall be slightly unbalanced at higher voltages to compensate for the loss caused by a protective coil across the load circuit.

A further object of the invention is to provide a monocyclic square regulator that shall have the air-gaps increased and the cross-sectional area of the magnetic material decreased in the magnetic circuits of the inductive arms of the square for unbalancing the square at higher voltages to compensate for the loss of current caused by a protective coil across the load circuit.

In a monocyclic square regulator for supplying constant current, the two equal capacity arms and the two equal inductive arms offer equal reactances to currents of the same frequency. The arms of the square are tuned to the frequency of the supply current. The square when supplied with constant potential alternating current tends to maintain constant current on the load circuit under various load conditions but if the load circuit is opened, the square will be subjected to excessively high voltages. The high voltages thus produced tend to destroy the condensers in the capacity arms. In order to protect the monocyclic square against excessively high voltages when the load circuit is opened, it has been proposed to connect a saturated reactor across the load circuit. The magnetizing current drawn by the saturated reactor upon opening of the load circuit serves to protect the square against excessive voltages. However, the protective coil tends to draw an increasing amount of current as the load circuit voltage increases and this tends to interfere with the quality of the regulating operation.

According to the present invention, it is proposed to unbalance the square varying amounts and compensate at higher voltages for the loss caused by the protective coil. A monocyclic square may be unbalanced by changing the capacity arms or by changing the inductive arms. In order to compensate for the current taken by a protective coil the square must not only be unbalanced but must be unbalanced varying amounts so that an increasing amount of current is supplied to the load circuit at higher voltages. If the square is unbalanced a slight amount and the reactance values of the arms of the square do not change the output characteristic of the square will not be changed and only a change in the level of the output current will be effected. The unbalancing of the square is preferably effected by increasing the air-gaps and decreasing the cross-sectional area of the magnetic material in the magnetic circuits for the inductive arms of the square. In the preferred form of the invention, the two windings for the inductive arms of the square are mounted on the same core in order to have the same inductive reactances. The core may have three legs with the windings mounted on the central leg. An air-gap is generally placed in the magnetic circuit of each winding in order to insure that the impedances of the inductive arms are proportional. It has been found that by varying the air-gaps and by varying the cross-sectional area of the magnetic material in the magnetic circuits of the inductive arms for the square under or over compensation by the regulator may be effected. Increasing the air-gaps in the magnetic circuits of the inductive windings in the square will increase the current in the inductive windings and increase the current supplied to the load circuit. Decreasing the air-gaps in the magnetic circuits of the inductive windings will decrease the current in the inductive windings and decrease the current supplied to the load circuit. The reluctance of the magnetic circuits for the inductive windings of the square may be controlled by varying the cross-sectional area of the magnetic material or by varying the air-gap and the cross-sectional area of the magnetic material. If the air-gap only in the magnetic circuits is varied the reactance values of the arms of the square will remain constant and the voltage current characteristic of the inductive windings will be a straight line. In border line conditions for very small changes in the magnetic circuit the above condition may not exactly hold. If the air-gap and the cross-sectional area of the magnetic material are changed, reactance values of the arms of the square will vary slightly and the voltage current characteristic of the inductive windings will not be a straight line. It is apparent that separate cores for the two windings of the inductive windings may be provided if so desired.

In the regulator employed to illustrate the invention, the air-gap is increased and the cross-sectional area of the magnetic material is re-

duced in the magnetic circuits of the inductive arms to over-compensate the regulating operation at higher voltages. This over-compensation serves to compensate for the loss effected by the protective coil which is connected across the output circuit of the square. The compensation effected by controlling the magnetic circuits increases with increased voltage in the same proportion that the loss effected by the protective coil increases with increased voltage.

In the accompanying drawing:

Fig. 1 is a diagrammatic view of a monocyclic square regulator constructed in accordance with the invention;

Fig. 2 is a diagrammatic view of the inductive windings in the monocyclic square shown in Fig. 1;

Fig. 3 is a set of curves showing the change effected in the current of the inductive arms of the square at higher voltages to unbalance the square; and

Fig. 4 is a set of curves showing the compensation effected by unbalancing the square at higher voltages.

Referring to Fig. 1 of the drawing, a monocyclic square 1 comprising two capacity arms and two inductive arms is shown connected to a source of alternating current 2 by means of a transformer 3. The two capacity arms of the square 1 comprise condensers 4 and 5 and the two inductive arms comprise inductance windings 6 and 7. The output vertices of the square are connected to a suitable load 8. A protective coil 9 which is wound on a saturated core 10 is connected across the load circuit. The protective coil 9 serves to insure the square 1 against excessively high voltages in case the load circuit is opened.

Heretofore, monocyclic square regulators of the above type have been constructed with arms having equal impedances. In such a regulator, the load circuit will be supplied with constant current if the square is supplied with alternating current of constant potential. In the above supposition, it is assumed that the frequency of the alternating current is maintained constant. The protective coil 9 draws a certain amount of current which increases as the voltage on the load circuit increases. This current drawn by the protective coil tends to interfere with the quality of the regulation effected by the monocyclic square. In order to compensate for the current drawn by the protective coil 9 the reluctance of the magnetic circuits for the windings 6 and 7 is varied. The air-gap of the core for the windings 6 and 7 of the inductive arms is increased and the cross-sectional area of the magnetic material is reduced so that an over-compensation is effected. The parts of the square are so designed that this over-compensation serves to take care of the current drawn by the protective coil 9 at higher voltage operations.

Referring to Fig. 2 of the drawing, the windings 6 and 7 of the inductive arms for the square 1 are shown mounted on the central leg 11 of a three-legged core 12. Two air-gaps 13 and 14 are shown in the magnetic circuits for the windings 6 and 7 including the central leg 11 of the core 12. In accordance with the invention, the air-gaps 13 and 14 are increased and the cross-sectional area of the core 12 is reduced so that the impedances of the inductive arms of the square 1 are not equal to the impedances of the capacity arms at higher voltage operations. In other words, the monocyclic square 1 is unbalanced slightly at higher voltage operations. This unbalancing of the monocyclic square tends to over-compensate the regulating operation and to take care of the current drawn by the protective coil 9.

Referring to Fig. 3 of the drawing, three curves A, B and E illustrate the characteristics of the windings 6 and 7 in inductive arms of the square 1 when the square is unbalanced and when the square is maintained in balanced condition. The curves A, B, and E are drawn with the current through the windings 6 and 7 as ordinates and the potentials impressed across the windings 6 and 7 as abscissae. The curve B illustrates the voltage current characteristic of the windings 6 and 7 in a balanced monocyclic square wherein the current and voltage of the windings 6 and 7 are proportional to each other at all points in the operation of the square. The curve A illustrates the voltage current characteristic of the windings 6 and 7 in a square which has been slightly unbalanced by increasing the air-gaps 13 and 14. If the windings 6 and 7 have a linear characteristic A the output from the square will be raised, but the shape of the output characteristic from the square will not be changed. Windings 6 and 7 with a characteristic A will not compensate for the current drawn by the protective coil 9. The curve E illustrates the voltage current characteristic of the windings 6 and 7 in a square which has been slightly unbalanced not only by reducing the cross-sectional area of the magnetic material in the magnetic circuits, but also by increasing the air-gaps 13 and 14. The change in the cross-sectional area of the magnetic material in the magnetic circuit will be effected by varying the size of the core 12 shown in Fig. 2 of the drawing.

Referring to Fig. 4 of the drawing, two curves C and D are drawn with volts output from the square as abscissae and amperes output from the square as ordinates. The curve C illustrates the characteristic of a monocyclic square regulator as shown in Fig. 1 of the drawing in which the square is slightly unbalanced in the manner above set forth by increasing the air-gaps 13 and 14 and reducing the cross-sectional area of core 12 to compensate for the current drawn by the protective coil 9. The curve D illustrates the characteristic of a monocyclic square regulator as shown in Fig. 1 of the drawing, in which the square is not unbalanced in the manner above set forth.

In a typical unbalanced regulator designed to give a constant load current and to operate between 160 and 600 volts as illustrated by characteristic C, it is shown that approximately $a +$ or $-$ 4% variation from constant current is obtained between these operating voltages, whereas characteristic D illustrates the same regulator but with balanced bridge arms and giving $a +$ or $-$ 2.1% variation from constant current between the above mentioned operating voltages. Changes in the constant current level furnished to the load circuit may be obtained by changing the value of the constant applied voltage impressed on the bridge 1. Such changes in the impressed constant input voltage across the bridge may be obtained by the use of taps on either the primary winding or secondary winding of the transformer 3. The saturated core 10 of the protective coil 9 is assumed to be composed of silicon steel, but if so desired may be composed of an alloy of nickel-iron in the manner disclosed

in the application of S. F. Farkas and L. B. Hilton, Serial No. 64,699, filed February 19, 1936.

Modifications in the circuits and in the arrangement and location of parts may be made within the spirit and scope of the invention and such modifications are intended to be covered by the appended claims.

What is claimed is:

1. In combination, a monocyclic square having two vertices connected to a constant potential source of alternating current and the other two vertices connected to a load circuit, said square having two capacity arms and two inductive arms, a protective winding mounted on a core operating at high flux densities, said winding being connected across the output circuit of the square to protect the square in case the load circuit is opened, and means to effect a slight varying unbalance of the square in a direction to increase the current output from the square when operating at higher voltages to compensate for the current drawn by said protective winding.

2. In combination, a monocyclic square having two vertices connected to a constant potential source of alternating current and two vertices connected to a load circuit, said square having two capacity arms and two inductive arms, means for controlling the two inductive arms to effect a slight varying unbalance of the square in a direction to increase the current output from the square when operating at higher voltages, and a reactor having a core operating at high flux densities connected across the output circuit of the bridge to protect the square in case of open circuit conditions.

3. In combination, a monocyclic square having two vertices connected to a constant potential source of alternating current and two vertices connected to a load circuit, said square having two capacity arms and two inductive arms, and means for effecting a slight varying unbalance of said square according to the load thereon.

4. In combination, a monocyclic square connected to a source of alternating current and having two capacity arms and two inductive arms, the two inductive arms comprising two windings on one core with a variable reluctance to slightly unbalance the square varying amounts at higher voltage operations, a reactor having a saturated core connected across the output vertices of said square for protecting the square in case the load circuit is opened, the unbalancing of the square caused by the variable reluctance core carrying the windings of the inductive arms serving to compensate for the current drawn by said reactor and to extend the range of the regulating operation.

5. In combination, a monocyclic square having two capacity arms and two inductive arms, said two inductive arms comprising two windings on a single core, means for controlling the reluctance of the magnetic circuits through said core for effecting a varying unbalance of the square in a direction to increase the current output from the square when operating at higher voltages, and a protective winding mounted on a core operating at high flux densities, said protective winding being connected across the output circuit of the square to protect the square in case the load circuit is opened.

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