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H. WEICHSEL.

METHOD OF COMMUTATING ALTERNATING CURRENT ELECTRIC MOTORS.

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Fig. 1.

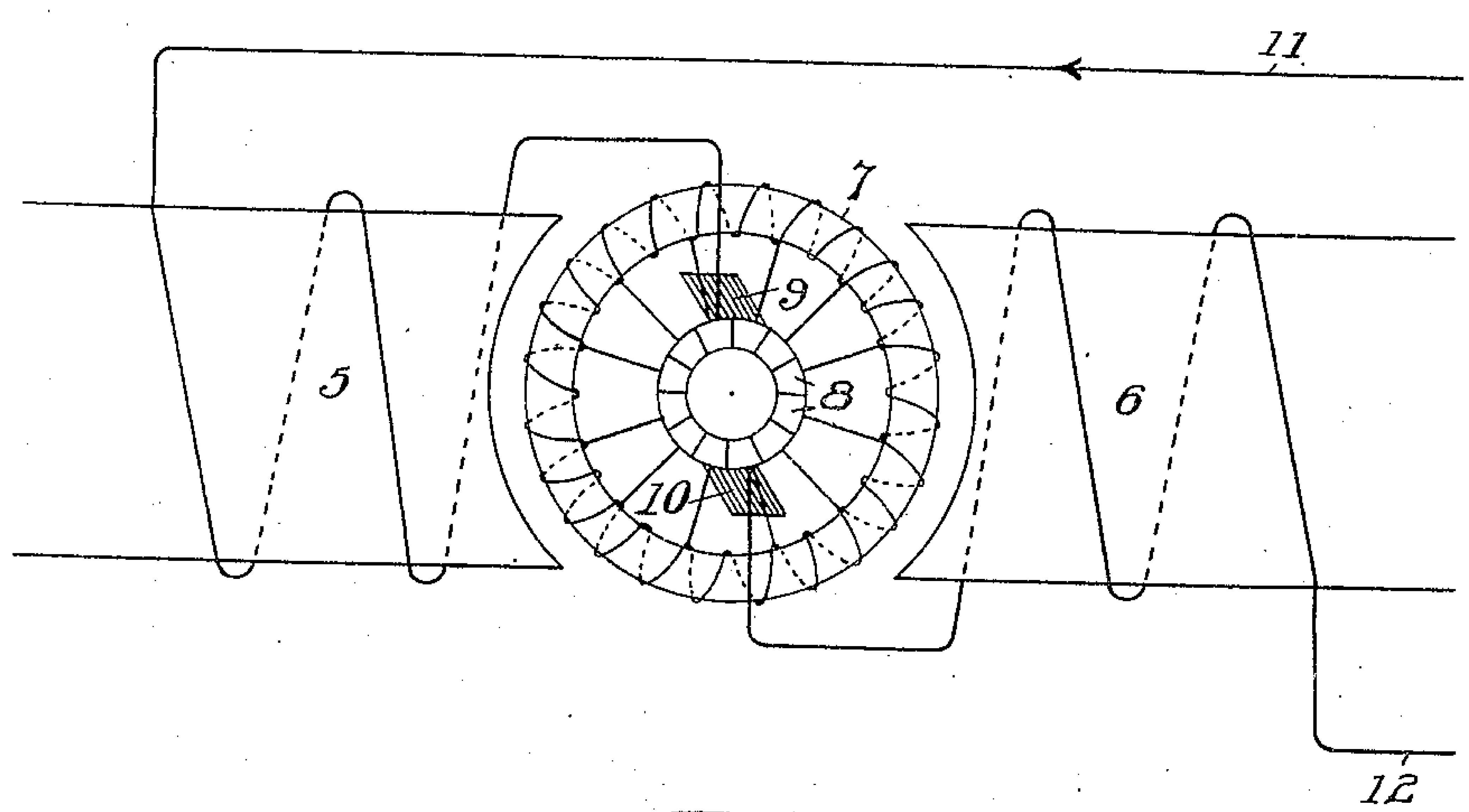
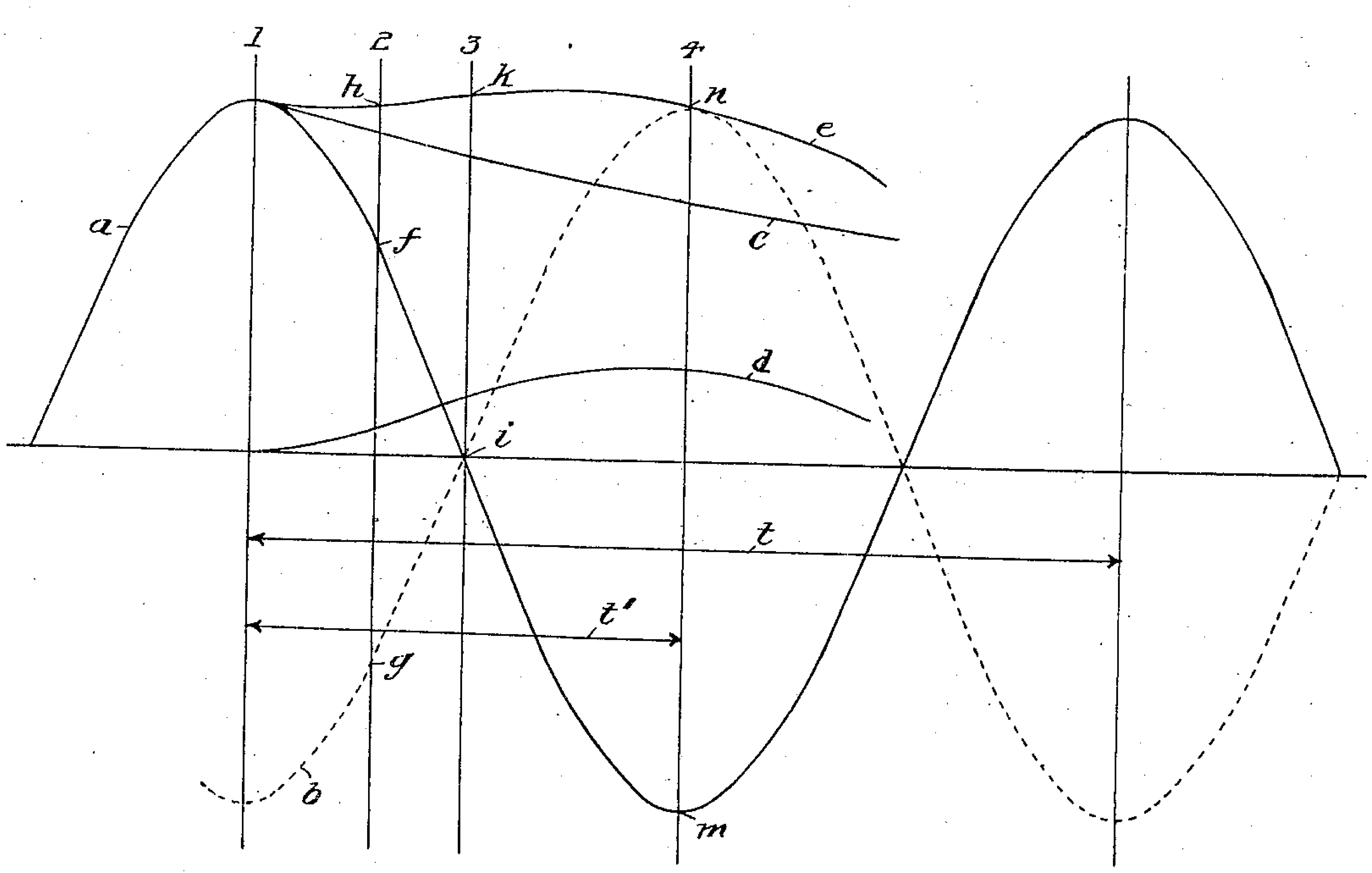


Fig. 2.



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METHOD OF COMMUTATING ALTERNATING-CURRENT ELECTRIC MOTORS.

No. 828,077. Specification of Letters Patent. Patented Aug. 7, 1906.

Application filed August 28, 1905. Serial No. 276,015.

To all whom it may concern:

Be it known that I, HANS WEICHSEL, a subject of the German Emperor, residing at Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented certain new and useful Improvements in the Method of Commutating Alternating-Current Electric Motors, of which the following is a specification, reference being had therein to the accompanying drawings.

This invention relates to a method of commutating alternating-current electric motors; and its object is to prevent, or, at least, greatly reduce, the sparks at the commutator-brushes. This result is secured by maintaining the short circuit of the armature-coils for one-half of the period of the current, or approximately so.

In the accompanying drawings, Figure 1 is a diagrammatic view of the motor-windings and commutator, and Fig. 2 is a diagram showing the characteristics of the current in my method of commutating.

The motor will be of any type of alternating-current commutator-motor—that is, either a series-wound motor or an induction commutator-motor. The motor shown in Fig. 1 has the field-coils 5 and 6 and armature-coils, which are represented as an ordinary Gramme ring 7, the individual coils of which are connected to the commutator-bars 8. The commutator-brushes 9 and 10 bear upon these bars in the usual manner, and one thereof is connected to the one field-coil 5 and the other to the other field-coil 6. One of the line-wires 11 is connected to the field-coil 5, and the other line-wire 12 is connected to the field-coil 6. There is nothing new in this arrangement of motor, and it has been selected merely for purpose of illustration.

In all alternating-current motors as at present constructed and operated a considerable amount of sparking takes place at the commutator-brushes. These sparks are due to a difference in the strength or direction of the current flowing through a given armature-coil at the time of breaking the short circuit thereof and the current which must flow through that coil immediately after the short circuit is broken. As is well known, the commutation is effected by the brushes bridging adjacent commutator-bars, thus short-circuiting a coil of the armature for the period of time during which the brush bridges these bars and breaking said short circuit when the brush passes off one of said bars. Before the commutation begins the current through the armature-coil is in the same direction as the line-current, but after the commutation—that is, after the short circuit is broken—the current through the said coil is opposite to the line-current.

The sparks are due to the fact that the period of commutation—that is, the period of maintaining the short circuit of the coil—is of such brief duration that it is broken at a time when the current flowing through the coil is opposite to that which must flow through that coil immediately thereafter. This may be explained by the diagram Fig. 2. In said figure we will suppose the line *a* to represent the line-current, *t* being the time period thereof and *t'* one-half of said period. The dotted line *b* represents the current which must flow through the observed armature-coil immediately after the breaking of the short circuit—that is, the commutated line-current—this current being opposite to the external line-current *a*. If now we suppose the period of commutation—that is, the period of short-circuiting the observed coil—begins at the maximum of the line-current—namely, at 1—when this occurs, the line-current no longer flows through the short-circuited coil, but through the adjacent coil. During this short-circuiting, however, current will flow through the short-circuited coil, this current having two factors. One of said factors is the residuum of the line-current. If the coil had absolutely no reactance, the current through it would drop to zero immediately upon the making of the short circuit; but as all coils necessarily have reactance the current will die down gradually, the rate of drop depending upon the ratio of the resistance of the coil to its reactance. This current may be represented by the line *c*. The other factor of the current flowing through the short-circuited coil is the induced current produced by the position of the close-circuited coil in the magnetic field and the rise and fall of said field. This induced current is represented by the line *d*. It starts at zero and gradually rises to a maximum. This induced current and the residuum current *c* are both in the same direction, (in the diagram being shown as positive,) and the sum or resultant of said currents is represented by the line *e*. This is approximately a horizontal line. If now we suppose the time of commutation to end at 2, (as in the present practice,) the line-current will be at *f*. The current which must flow through the observed coil immediately after breaking the short circuit must be equal to but in the opposite direction to the line-current—that is, it will be negative and at *g*; but the current *e*, flowing through the observed coil at the time of breaking the short circuit, is at *h* and is positive. The difference between the resultant current at *h* and the current which must flow through the coil after the breaking at *g* will cause a large spark at the commutator-brush. If now we prolong the time of commutation, so that it will end at 3, the line-current will have dropped to zero—namely, to *i*—and the current which must flow through the observed coil immediately after commutation will also begin at zero; but the current *e*, flowing through the coil at the time of breaking, will be positive and at *k*, and hence a spark will result; but it will not be as large as when the commutation ended at 2. Suppose now that the period of commutation be prolonged to end at 4. The line-current will now be negative and at a minimum—namely, at *m*—and the current which must flow through the observed armature-coil immediately after commutation will be equal thereto and in the opposite direction—that is, it will be at *n*. The current *e*, flowing through the coil at the time of breaking the short circuit, is also positive and is likewise at *n*. Hence the current flowing through the coil at the moment of breaking and that which must flow through the coil immediately thereafter are of equal value and in the same direction. Consequently no spark will result.

In motors as at present constructed and operated the time of commutation is considerably less than one-fourth of the period of the current and may fairly be represented by the line 2. This, for the reasons above stated, causes large sparks; but by continuing the period of commutation for approximately half of the period of the line-current—namely to the point 4—no spark will result.

In actual practice the current *e*, flowing through the armature-coil during commutation, and the current *b*, which must flow through the coil immediately after commutation, may not be exactly equal at the point 4. Nevertheless they will be approximately equal, so that the amount of sparking is negligible. To get the best results, the short circuit of the coil must be broken when the current flowing in the coil has most closely approached the current which must flow through the coil after commutation. This, as illustrated, is after a half-period of the line-current. This time, however, will vary slightly, depending upon the electrical characteristics of the armature-coils—such as their resistance, reactance, capacity, &c.; but with a properly-designed motor it will be approximately after a half-period of the line-current.

The period of commutation will of course depend upon the speed of rotation of the armature. The motor will therefore be designed to maintain the short circuit during a half-period of a current of such frequency as the motor is designed for and while running at its average speed or speed of greatest efficiency.

The desired length of commutation may be obtained by making the commutator-brushes of sufficient width to bridge adjacent commutator-bars for the desired period, or by changing the lengths or shapes of the commutator-bars themselves, or in any other suitable way.

While the diagram in Fig. 2 illustrates the commutation as beginning at the maximum of the line-current and ending at the minimum thereof, this is done merely for simplicity of illustration and explanation. The same results will follow at whatever point in the line-current the short circuit begins, it only being necessary to continue said short circuit during a half-period of the current.

While in the claims it is stated that the period of commutation is continued during a half-period of the line-current or that it is maintained until the line-current is equal to the current flowing through the coil, it will be understood that these phrases are only approximate and that they include all arrangements wherein the commutation ends at the time when the line-current most closely approaches in strength the current flowing through the coil, even though these two currents should not be exactly equal or this should not occur exactly at the half-period of the line-current.

What I claim is—

1. The method of commutating alternating-current motors which consists in maintaining the short circuit of the armature-coils during a half-period of the line-current.

2. The method of commutating alternating-current motors which consists in maintaining the short circuit of a given armature-coil until the commutated line-current is equal to, and in the same direction as, the current flowing through said armature-coil; and at that moment breaking the short circuit.

In testimony whereof I affix my signature in presence of two witnesses.

HANS WEICHSEL.

Witnesses:
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