No. 808,064. PATENTED DEC. 26, 1905.

E. ARNOLD & J. L. LA COUR.

COMMUTATOR MOTOR.

APPLICATION FILED DEC. 16, 1904.

Fig. 1

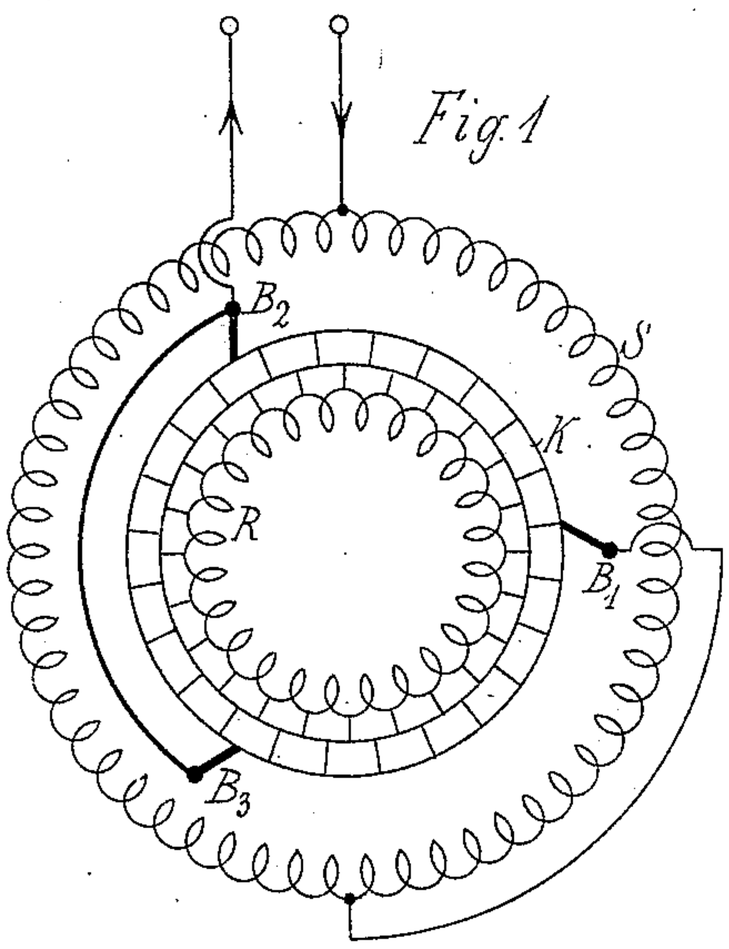


Fig. 2

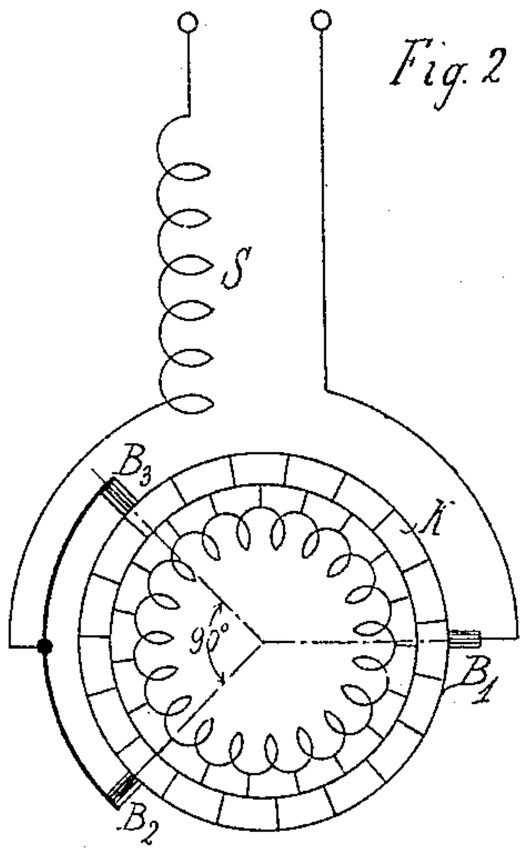


Fig. 3

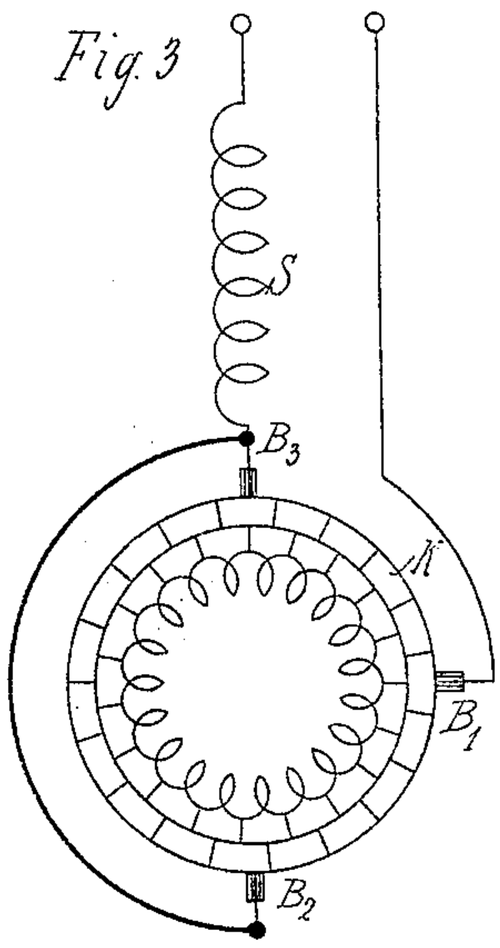
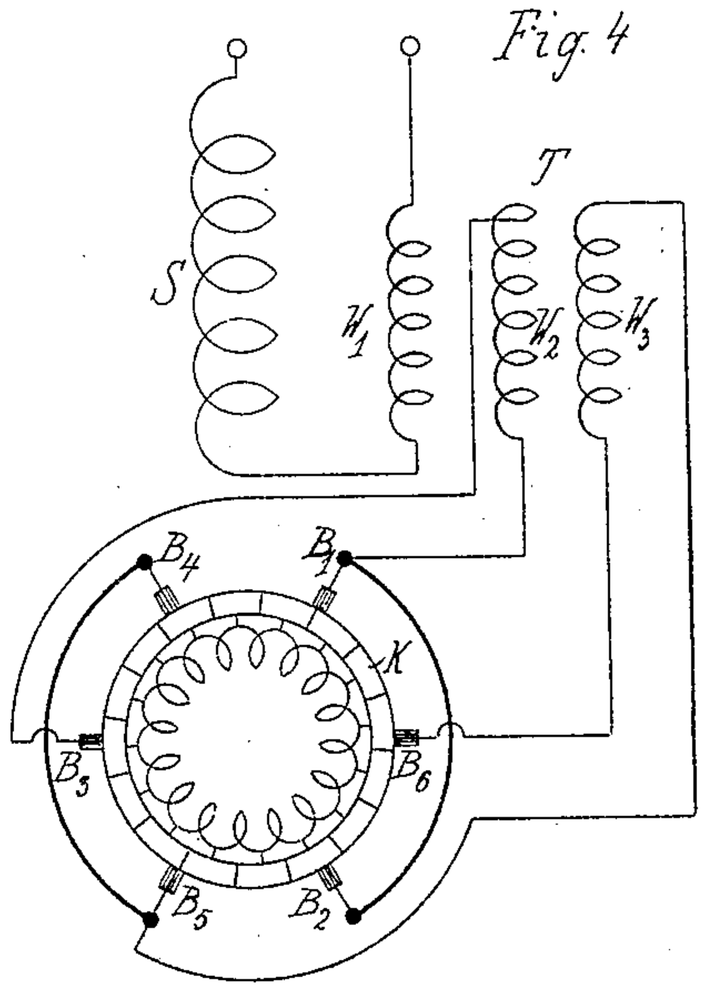


Fig. 4



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COMMUTATOR-MOTOR.

No. 808,064. Specification of Letters Patent. Patented Dec. 26, 1905.

Application filed December 16, 1904. Serial No. 237,156.

To all whom it may concern:

Be it known that we, ENGELBERT ARNOLD, of Karlsruhe, Germany, and JENS LASSEN LA COUR, of Edinburgh, Scotland, have invented certain new and useful Improvements in Commutator-Motors, of which the following is a specification.

In the arrangement that is proposed by Winter and Eichberg and by Latour in order to compensate the difference of phase in single-phase alternating-current motors at the commutator of a bipolar motor four brushes are required. One of the brushes leads in, another leads off either the main or shunt current. The other two, arranged at right angles to the aforementioned brushes, are short-circuited. The current that passes through the first pair of brushes produces in the rotor a field perpendicular to the field which would be produced by the stator-current if the second short-circuited pair of brushes did not exist. By short-circuiting the second pair of brushes, first, the stator-field is destroyed, and, secondly, in the rotor-winding a current will flow which lags nearly ninety degrees behind the main current. Each of these rotor-currents produces a field of triangular shape that may be split up into fundamental sine-waves and higher harmonics. Concerning the matter of splitting up the field it may be stated that it is well known that where the intensity of an alternating current is represented as a function varying with the time that a periodical wave is obtained such a periodical wave can be split up in several other ways. The best known manner of splitting up such waves is proposed by Fourier. According to his method the original wave is split up into a number of sine-waves, one wave having the same number of periods as the original and the others having numbers of periods which are multiples of the periods of the original waves. The sine-wave, as mentioned, is called the "fundamental sine-wave," while others are called "higher harmonics." In the book *Die Wechselstromtechnik*, by E. Arnold, and published by J. S. Springer, of Berlin, the above method of splitting up waves is described on pages 145 to 152, inclusive. These higher harmonics are, as well known, very great when the armature-winding is not carried out in the mode described in the English Letters Patent No. 5,064 of 1898 to B. G. Lamme.

In the present invention to avoid the great number of brushes and the great higher harmonics of the compensated motors of Winter and Eichberg and Latour we propose the application of three brushes which are set at angles of one hundred and twenty degrees to one another. Two of these brushes are short-circuited and so arranged that the total stator-field is destroyed. The current is sent into the rotor through the third brush and taken off by means of the two short-circuited brushes. Consequently in a bipolar dynamo the rotor-current produces also in this case a field perpendicular to the field produced by the stator-current. Hence we get by means of three brushes exactly the same result as Winter and Eichberg and Latour by means of four brushes. In the proposed arrangement of three brushes the rotor-fields will more nearly approach in shape to sine-waves than with the arrangement of four brushes, and by the three-brush arrangement proposed the current is always flowing through turns lying on two-thirds of a double-pole pitch. Thus the same advantage as with three-phase alternators and with single-phase alternators where only two-thirds of the circumference is wound is obtained. This advantage being that no third harmonics can exist, and therefore, the fifth harmonics being the first which come into consideration, the rotor-fields will more nearly approach sine-waves than with the former arrangement. In consequence the working capacity of the motor with three brushes will be greater. By shifting the brushes it is made possible with the same load to vary the number of revolutions and the power factor of the motor. Hence in theory the brushes may be set in different positions. In general, however, they are left set, as above stated, in such a position that the field produced by the stator-current will be almost entirely destroyed.

In the accompanying drawings, Figure 1 is a diagrammatic representation of a series motor embodying the invention. Figs. 2, 3, and 4 are diagrammatic representations of different embodiments.

Fig. 1 of the accompanying drawings represents the diagram of such a series motor. S is the stator-winding, which here is represented as a continuous-current winding. R is the rotor-winding, and K the commutator. The stator-current is led into the rotor-winding through the brush B′, and taken off by

means of the two short-circuited brushes B^2 and B^3. It is, however, not necessary to set the brushes at angles of one hundred and twenty degrees exactly. The motor will work very well even when the two short-circuited brushes are set between ninety degrees and one hundred and eighty degrees in relation to each other.

Fig. 2 represents the bipolar scheme of a compensated single-phase series motor having three brushes, wherein the two short-circuited brushes B^2 and B^3 are set at ninety degrees. S is the stator-winding, K the commutator, and B′ the third brush which conveys the main current. Fig 3 represents such a motor when two short-circuited brushes B^2 and B^3 are set at one hundred and eighty degrees and the third brush is set at ninety degrees relatively to these.

When large currents are to be led into rotor-winding, it is advantageous to double the number of brushes per pair of poles in order to best utilize the commutator and the armature-winding. In order not to lose the advantages of the three-brush connection, such doubling of brushes can be attained by arranging two groups each consisting of three brushes per pair of poles. These two groups of brushes have no direct connections with each other exterior to the commutator. Thus the same current is led to each of the groups of brushes as though the other group did not exist. The distribution of current at each group of three brushes and at the armature remains as though there was only one group of three brushes. So the motor with two groups of three brushes per pair of poles possesses the same working advantages as that having one such group only.

Fig. 4 represents the bipolar diagram of connections of the series motor with two groups each of three brushes. S is the stator-winding. T is a series transformer. W′ is the primary winding; W^2 and W^3, two secondary windings. W^2 feeds the armature through the group of brushes B′, B^2, B^3 and W^3 through the group B^5 B^4 B^6. In this figure all the brushes are placed at equal distances corresponding to sixty degrees. That, however, is not necessary. What is essential only in the arrangement of the brushes is this: that the armature-winding is short-circuited in nearly the same direction by each of the two pairs of brushes. Of course in multipolar dynamos the number of brushes which may be used is six times as much as the number of pairs of poles. With wave-windings, however, it is not needed to use all the brushes. In such case six brushes are sufficient, being suitably distributed around the circumference of the commutator.

What we claim as our invention, and desire to secure by Letters Patent of the United States, is—

1. A compensated single-phase alternating-current commutator-motor with three brushes, in a bipolar scheme, which are set relatively to each other at angles of one hundred and twenty degrees and of which three brushes two short-circuited brushes are used for introducing and the third brush for taking off the magnetizing-current, substantially as hereinbefore described.

2. A compensated single-phase alternating-current commutator-motor with three brushes, in a bipolar scheme, which are set relatively to each other at angles that differ more or less from one hundred and twenty degrees and of which three brushes two short-circuited brushes are used for introducing and the third brush for taking off the magnetizing-current, substantially as hereinbefore described.

3. The combination with a compensated single-phase alternating-current commutator-motor comprising two groups of three brushes each, the three brushes of each group being set at angles of one hundred and twenty degrees to each other and two of the three brushes of each group being short-circuited, of connections for introducing the magnetizing-current, one terminal of said connections being connected to the two short-circuited brushes of a group while the other terminal of said connections is connected to the remaining brush of that group, the two groups of three brushes being unconnected exterior to the commutator and placed to short-circuit the armature-winding in approximately the same direction by the pair of short-circuited brushes of each group, substantially as described.

In testimony whereof we have signed our names to this specification in the presence of the subscribing witnesses.

ENGELBERT ARNOLD.
JENS LASSEN LA COUR.

Witnesses for Engelbert Arnold:
WOLDEMAR HAUPT,
HENRY HASPER.

Witnesses for Jens Lassen la Cour:
JAMES PHILLIPS,
GEORGE BRAID.