R. H. CUNNINGHAM.

MAGNETO ELECTRIC GENERATOR.

APPLICATION FILED OCT. 8, 1912.

1,181,996.

Patented May 9, 1916.

2 SHEETS—SHEET 1.

Fig. 1

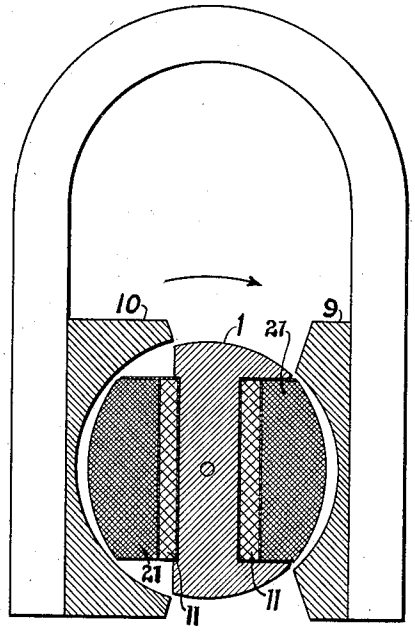


Fig 3

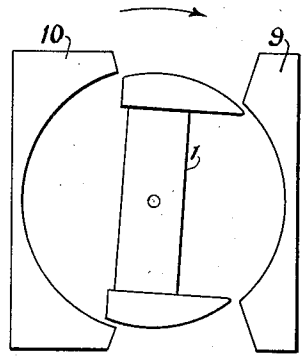


Fig. 2

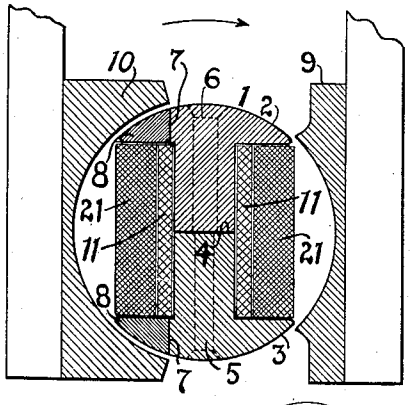
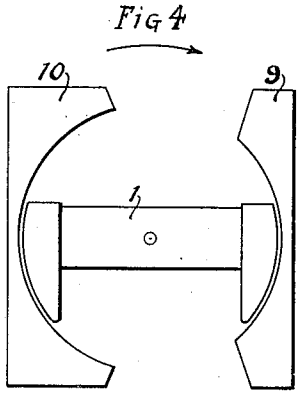


Fig 4



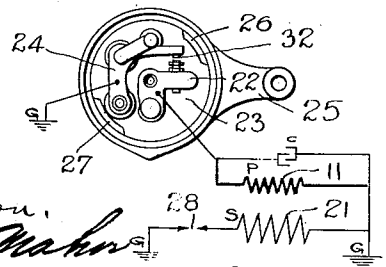


Fig. 10.

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2 SHEETS—SHEET 2.

Fig. 5

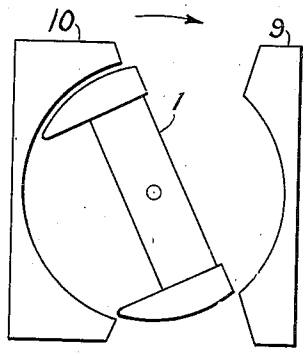


Fig 6

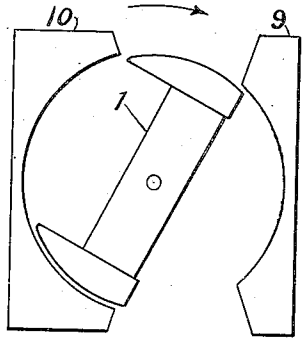


Fig 7

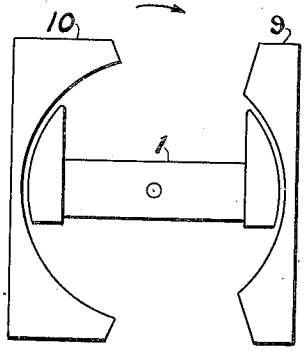


Fig. 9.

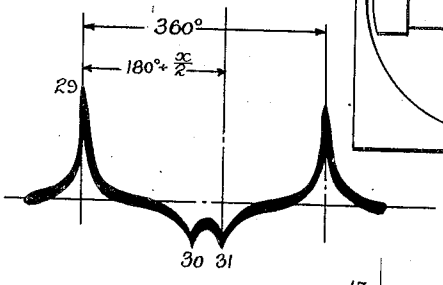
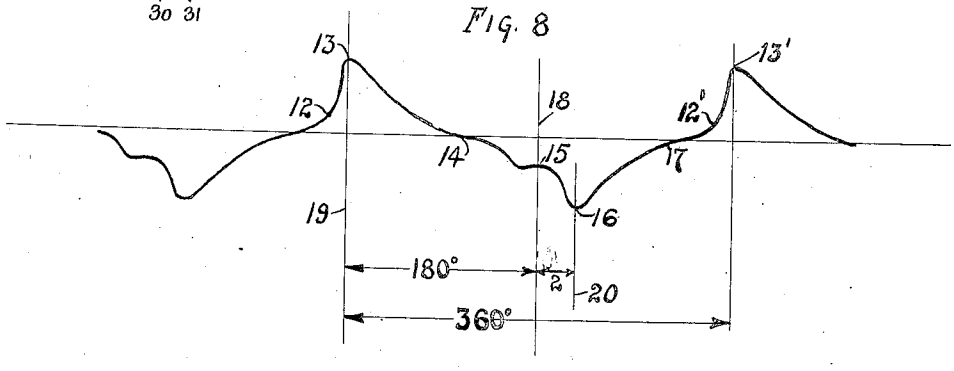


Fig. 8



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UNITED STATES PATENT OFFICE.

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MAGNETO-ELECTRIC GENERATOR.

1,181,996. Specification of Letters Patent. Patented May 9, 1916.

Application filed October 8, 1912. Serial No. 724,528.

To all whom it may concern:

Be it known that I, RICHARD H. CUNNINGHAM, a citizen of the United States, a resident of New York city, borough of Manhattan, in the county of New York and State of New York, have invented certain new and useful Improvements in Magneto-Electric Generators; and I do hereby declare the following to be full, clear, and exact description of my invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to magneto-electric generators employed for ignition purposes in connection with internal combustion engines, and more particularly to generators adapted for use in connection with the class of engines which is commonly employed to propel motor bicycles, motor tricycles, and small four wheeled motor vehicles. When such engines are of the two cylinder type, the two piston rods usually act on a common crank and the axes of the two cylinders, which are disposed in the plane of the crank, converge toward the axis of the crank shaft; the angular inclination between said cylinder axes varying according to the design of the engine. The explosive mixture in the respective cylinders should be fired at the points of maximum compression in said cylinders and the respective cycles of one cylinder should follow those of the other at an angular interval as close as possible to 360 degrees. The angular disposition of the cylinders however necessitates a variation in this interval so that it becomes alternately greater and less than 360 degrees by an amount equal to the angle between the cylinder axes. In other words, if the angular inclination of the cylinders to each other be denoted by the symbol X, the explosions will occur at an interval of 360 degrees $\pm$ X, and since the armature of the two pole magneto must rotate at half crank-shaft speed to produce sparks at periods corresponding to the proper explosive cycle, the sparks produced by the action of the magneto should occur at intervals of 180 degrees $\pm \frac{X}{2}$. As an ordinary magneto with symmetrically shaped pole pieces and a symmetrical H-shaped armature yields symmetrical positive and negative current half waves with their maxima separated by an interval of 180 degrees, it is evident that in order to produce current half waves with maxima separated by intervals of 180 degrees $\pm \frac{X}{2}$, a distortion of one or of both half waves must occur. Now, it is a well established fact that every distorted wave, or half wave, is the result of the combination of a fundamental wave with a superimposed harmonic or harmonics of different periodicity, which may or may not be in phase with the fundamental wave. Hence it is evident that by superimposing a harmonic or harmonics of the proper frequency and amplitude upon the usual fundamental wave or preferably upon alternate half waves such as are ordinarily produced by a magneto alternating current generator, it is possible to produce a distorted wave the maxima of the positive and negative half waves of which will occur at intervals approximately equal to 180 degrees $\pm \frac{X}{2}$, provided that the angle X is comparatively small.

It is the object of my invention to produce this requisite distortion of one or the other current half wave or half waves or both, and in the embodiment of the invention herein set forth such distortion is effected by modifying the contour of the pole pieces and armature in a novel manner. In the exemplification of my invention shown in the accompanying drawings, the magnetic portion or portions of the magneto armature are substantially U-shaped in cross section rather than H-shaped as they have heretofore been constructed. A suitable winding or windings are provided in connection therewith so that by the revolution of such armature in the magnetic field between the pole pieces every other resulting E. M. F. half wave or current half wave is so distorted that the maxima of the two half waves occupy such a position with reference to each other as to approximately fulfil the conditions required by the formula 180 degrees $\pm \frac{X}{2}$.

In the drawings which form a part hereof and in which like reference characters designate like parts throughout the several views; Figure 1 is a transverse section of the preferred form of the magneto, taken at right angles to the axis of the armature,

diagrammatically showing the magnetic pole arcs and asymmetrically channeled armature. Fig. 2 is a similar section of a modified form of the magneto. Fig. 3 is a similar section with the armature in the position in which the magnetic flux is undergoing a most rapid change. Fig. 4 is a similar section with the armature in the neutral position in which the terminal potential is zero. Fig. 5 shows the armature or revolving element about to break away from one of the pole pieces, producing a slight change in the magnetic flux. Fig. 6 shows the armature or rotating element, leaving the second pole piece, producing the maximum change of flux. Fig. 7 is a section showing the armature or rotating element in its second neutral position, in which the terminal potential is zero. Fig. 8 is a diagrammatic representation of the primary circuit current wave formed by such a magneto in operation, and illustrates the irregular shapes of the half waves, with certain of their maxima displaced the requisite number of degrees. Fig. 9 is a diagrammatic representation of the primary E. M. F., taken with substantially no current flowing from said primary winding. This curve is a reproduction of an oscillograph record from a machine same as shown in Fig. 1. Fig. 10 represents a circuit breaker which operates in connection with a cam holder carrying cams to engage a member of the circuit breaker; the method of connecting the windings shown in Fig. 1 is diagrammatically represented in Fig. 10.

Referring to Fig. 1, which is the preferred form of my invention, the armature therein shown has been broadly designated 1, and may be built up of laminations or thin sheet iron stampings, which may be held together by suitable end brackets and bearings in any well known manner, or it may be of one solid piece supported by suitable brackets and bearings. The pole pieces are represented by 9 and 10. On the armature or rotating element a primary winding #11 is represented, together with a secondary winding #21. In the modified form as shown by Fig. 2, the armature designated 1, is composed of two parts, which may, if desired, be laminated or built up of magnetic sheet materials in the usual manner. These members preferably abut against a layer of mica 4, or the like, to provide a gap therebetween, preferably passing through the armature axis. These parts are adapted to be held together by screws 5, which are in threaded engagement with interiorly threaded bolts 6, or the like, and the respective members 2 and 3 are preferably somewhat L-shaped, but preferably have also short extensions or ribs 7, projecting therefrom, so that when in assembled relationship, the magnetic portions of the armature may be defined as being channeled upon opposite sides thereof, with channels of unequal depth. In order to counterbalance the weight of the short or laterally projecting legs of the respective L-shaped members, I prefer to provide somewhat triangular shaped blocks or strips 8 of brass, or other relatively heavy non-magnetic material which have substantially the same general contour as the short legs, these blocks being secured to the members 2 and 3 in any suitable manner, thereby producing an armature structure mechanically H shaped.

In the preferred form of my invention shown in Fig. 1 I may or may not use the counterbalance weights shown in Fig. 2, as I may counterbalance the rotating part if necessary, in any other manner. It will thus be seen that the magnetic portions of the rotating element are substantially U-shaped in cross section, and are asymmetrically disposed with respect to a plane longitudinal of the armature and perpendicular to the plane of the two sides of the U-shaped section, and including the axis of rotation. It is also seen that the magnetic material of the rotating element is asymmetrically disposed with reference to a plane longitudinal of the armature and perpendicular to the plane of the coil, and including the axis of the coil. By axis of the coil is meant, the axis about which the coil rotates while it is being wound. Referring to Fig. 1, this would be a line passing through the center of rotation of the armature, and at right angles to the inner sides of the armature pole pieces.

The magnetic poles are preferably formed with arcs of unequal length. Pole 9, for example, shown upon the right side of the magneto, having in this instance, an arc of what might be termed normal length, while pole 10 has an arc of materially greater length. Stated in more general terms, what is cut off the pole pieces (which are the parts that bridge the field pole pieces, or they are the sides of the H armature of Fig. 2) of the armature in degrees measured on the periphery of the armature is added to the pole tips of one of the magnet pole pieces, such as 10. The usual primary coil or coils, 11, may be carried by the armature or rotating element, and with the exception of the changes herein indicated, the remaining parts of the magneto may be constructed and arranged, if desired, in accordance with the usual practice.

Considering now the actions of the magnetic flux and current wave, and referring to Fig. 8 in connection with the respective diagrammatic representations of the magneto parts, the point 12 or proximate thereto, corresponds to the armature position shown in Fig. 1, so that when the armature is being rotated in the direction indicated by the arrows in the respective figures from

the position indicated in Fig. 1 to that indicated in Fig. 3, the current wave will ascend from point 12 to point 13, the rise being relatively abrupt although the change in the position of the armature is but slight. This maximum position of 13 is represented approximately by Fig. 3. Continued rotation of the armature around to the position represented in Fig. 4 will cause the current wave to descend to the point 14. At the time the armature is nearly horizontal, substantially no current will flow. As the rotating element continues to turn toward the position in Fig. 5, a reverse current begins to flow in the coil, and the point 15 of the lower half wave is reached shortly after the armature or rotating element leaves pole piece 9 of Fig. 5. It will thus be seen that between the points 14 and 15 a secondary crest has been formed. Continued rotation of the armature to the position shown in Fig. 6 will correspond to the formation of that portion of the current wave between points 15 and 16. This latter point like point 13 illustrates one of the maximum values of current flow, so that continued rotation of the armature into the horizontal position shown in Fig. 7 will bring us to the point 17 of the curve. Further rotation of the armature back to the position of Fig. 1 will bring us to point 12′, corresponding to the point 12 at which we started, but, disposed an angular interval therefrom of 360 degrees. It will be evident from an inspection of the diagram shown in Fig. 8 that point 13 will be correspondingly spaced 360 degrees from point 13′, while if a line 18 is drawn midway between points 13 and 13′, the distance from a line 19 drawn through point 13, to the said line 18, will correspond to the interval of 180 degrees. A line 20 drawn parallel to those aforesaid through point 16, will be spaced from line 18 by an angular interval substantially corresponding to $\frac{X}{2}$, and hence the current wave generated between the lines above described meets the required conditions.

In general, it may be stated that it is desirable to prolong the arc of one pole, and to cut off the arc of the pole tips of the rotating element to correspond, according to the angular displacement of the maximum of the current wave desired.

The armature core is wound as is the usual practice with a primary winding of a few turns of coarse wire 11, one end of said winding being connected to ground through the metallic parts of the armature, while the other end is connected to a stationary contact member 22 of a rotating circuit breaker 23 that is fastened to and rotates with the armature shaft. The movable member 24 of the circuit breaker is connected with the metal construction of the magneto and is thereby grounded. Associated with the circuit breaker 23 is a cam holder 25 carrying cams 26 and 27 which are spaced the proper number of degrees to correspond with the degree intervals required on the particular engine to which the magneto is to be applied. The cam holder 25 is adapted to be connected to a lever for the purpose of advancing or retarding it to change the time at which the breaker contact 32 is opened and thereby the time at which the spark is produced across the spark point 28. A condenser C is connected across the two members of the circuit breaker 22 and 24. A secondary winding 21 composed of a large number of turns of fine wire is disposed around the primary winding 11. One end is grounded as indicated in Fig. 10, and the other end connected to a spark plug 28. No distributer is shown, for the sake of clearness, but it will be understood that for a two cylinder engine a distributer spool with a segment inserted therein would be connected to one end of the secondary winding and distribute the current to the proper brushes which are connected to the engine cylinders. Without the use of the circuit breaker, shown in Fig. 10, the primary winding of the armature produces an E. M. F. wave such as shown in Fig. 9. From this figure it will be noticed that the peak of the curve indicated by 29 is formed when the armature is in the position of Fig. 3, while that part of the curve, indicated by 30, is formed by the armature in the position of Fig. 5, and that part of the curve indicated by 31 is formed by the armature in the position of Fig. 6. It will be seen from this curve that the impulses indicated by 30 and 31 are minor impulses as compared to the impulse indicated by 29, but it will be seen that the point 31 is spaced from the point 29 an angular distance of $180° + \frac{X}{2}$. Since the values of these minor waves 30 and 31 are much less than the major wave 29, it is necessary to provide means for "pushing over" as it were, the energy represented by the minor wave 30 so as to augment the minor wave 31 sufficiently to produce an impulse that will compare more closely to the major wave 29. The means for doing this is provided by the circuit breaker 23 which holds the primary winding closed the proper number of degrees, and on account of the self-induction in the armature the wave of Fig. 9 is distorted so that a current wave is produced as shown in Fig. 8, which has already been described.

In general therefore I have shown that the asymmetrical disposition of magnetic material in the rotary and preferably also of the stationary parts of a magneto electric generator is effective to produce a wave

which is non-sine in form and composed of a fundamental, and one or more harmonics, and displaced in the manner described.

It is seen that the maximum rates of change of flux are unequal. Obviously, also, by means of this construction, I am enabled further, to vary the maximum rate of change of flux corresponding to one half wave with respect to that corresponding to the next since as will be seen upon inspection of Fig. 8, the contour of the half waves adjacent to the crests 13 and 16 are different, and this difference may be increased or diminished by varying the superimposed harmonics, which may readily be accomplished by rendering the transverse cross-section of the magnetic portions of the armature and poles more or less asymmetrical.

While I have shown certain details and a preferred form of my invention, I do not wish to be limited by the exact details shown therein, as I am aware that numerous changes and alterations may be made, all of which I believe will come within the scope of the appended claims.

Having thus described my invention, what I claim is:

1. In a magneto electric generator, magnetic material disposed to form a path for the magnetic flux, said material comprising fixed parts and a rotatable part having a body and pole pieces attached substantially at right angles thereto, a conductive coil disposed adjacent to said material and adapted to be electrically influenced by changes in said magnetic flux, the magnetic material in both said fixed and rotatable parts being respectively asymmetrically disposed with respect to the line of intersection of two planes, one of said planes being a vertical plane at the center of the generator and at right angles to the fixed parts, the other a vertical plane at right angles to the first and including the axis of the coil and the axis of rotation whereby rotation of said rotatable part will produce a current wave in said coil when the latter is energized, which is different from a sine wave.

2. In a magneto-electric generator, two generative magnet pole pieces of unequal arcs, magnets associated therewith, an armature therebetween and a conductive coil carried by said armature, the magnetic material of said armature being asymmetrically arranged with respect to the axis of said coil, whereby said coil generates current impulses at longer and shorter intervals, which impulses may be utilized for producing sparks, as described.

3. In a magneto-electric generator, magnet pole pieces of unequal arcs, one of said poles being prolonged so that the arc thereof is materially in excess of ninety degrees an armature therebetween, and a conductive coil carried by said armature, the magnetic material of said armature being asymmetrically arranged with respect to the axis of said coil, whereby said coil generates current impulses at longer and shorter intervals, which impulses may be utilized for producing sparks, as described.

4. In a magneto-electric generator, magnetic material disposed to form a path for the magnetic flux, said material including magnet pole pieces and an armature, and a coil adapted to be electrically influenced by changes in the magnetic flux through said material, the material in said armature being mechanically H-shaped but magnetically U-shaped, the magnetic portion being asymmetrically arranged with respect to the axis of rotation thereof, and the magnet pole pieces also being asymmetric with respect to said axis.

5. In a magneto-electric generator, magnetic material disposed to form a path for the magnetic flux, said material including magnetic pole pieces and an armature, and a coil on said armature adapted to be electrically influenced by changes in the magnetic flux through said material, the material in said armature being magnetically U shaped, said magnet pole pieces and armature magnetic material being arranged asymmetrically with respect to a plane longitudinal of the armature and containing the axis of the coil, said coil axis passing through the axis of rotation, said plane being taken with the arms of the U shaped armature in a horizontal position, and with the magnetic pole pieces vertical.

6. In a magneto-electric generator, permanent magnets having two generative pole pieces of unequal arcs, each pole piece of itself being of uniform section transversely throughout its length, an armature therebetween and a conducting coil on said armature, the magnetic material of said armature being magnetically U shaped but asymmetrically arranged with respect to a plane longitudinally of the armature and containing the axis of the coil and the axis of rotation.

7. In a magneto-electric generator, magnetic materials disposed to form a path for the magnetic flux, said materials including magnetic pole pieces and an armature substantially magnetically U shaped, and a coil on said armature adapted to be electrically influenced by changes in the magnetic flux through said material, transverse sections of said materials being uniform throughout the length, the magnetic material of the armature and pole pieces being asymmetrically arranged with respect to a plane longitudinal of the armature and containing the axis of the coil and the axis of rotation, when the magnet pole pieces and the axis of the coil are vertical.

8. In a magneto-electric generator, a

source of magnetic flux, opposed pole pieces carrying said flux, an armature adapted to be rotated between said pole pieces, said armature having a body portion and pole pieces of magnetic material substantially at right angles to said body portion, a coil carried by said armature and adapted to be electrically excited by changes in the magnetic flux, said opposed pole pieces and the magnetic material of said armature being asymmetrically arranged with respect to a plane longitudinal of the armature and containing the axis of the coil and the axis of rotation, said plane being taken when the armature material between its pole pieces is in a vertical position and said flux carrying pole pieces are vertical.

9. In a magneto electric generator, magnet pole pieces, a rotatable part having a body portion and pole pieces of magnetic material substantially at right angles to the body portion, a conductive coil disposed adjacent to said rotatable part, the magnet pole pieces, taken in a vertical position being symmetrical with respect to a vertical plane at the center and at right angles to said pole pieces and asymmetrical with respect to a vertical plane at right angles to the first mentioned plane and including the axis of rotation and axis of the coil and asymmetrical with respect to the line of intersection of said planes, the magnetic material in said rotatable part being symmetrical with respect to the first mentioned plane and asymmetrical with respect to the second plane and asymmetrical with respect to the line of intersection of said planes, said rotatable part having its body portion in a vertical position.

10. In a magneto-electric generator, for producing sparks at alternately longer and shorter intervals, magnet pole pieces of unequal arcs, one of said pole pieces having a normal arc length, the other of said pole pieces having an arc length in excess of the first equal to the angular difference between said longer and shorter intervals, an armature between said magnet pole pieces and generative coils on said armature, said armature having a body portion and pole pieces substantially at right angles thereto, each of said armature pole pieces being reduced on the same side of the body portion an amount equal in angular degrees to one-half the excess length of the magnet pole piece having the larger arc.

11. In a magneto-electric generator, magnetic material disposed to form a path for the magnetic flux, said material comprising fixed parts and a rotatable part, said rotatable part having a body portion and pole pieces of magnetic material, substantially at right angles to the body portion, a conductive coil disposed adjacent to said material and adapted to be electrically influenced by changes in said magnetic flux, the magnetic material in both said fixed and rotatable parts being asymmetrically disposed with respect to a plane longitudinally of the armature and perpendicular to the line of intersection of the armature pole pieces and body portion including the axis of rotation at periods of approximate maximum effort of said coil, whereby rotation of the rotatable part will produce a current wave in said coil which is different from a sine wave.

12. In a magneto-electric generator the combination of a rotatable armature and a winding thereon, and having pole pieces reduced on opposite sides of a plane perpendicular to the axis of the winding, and containing the axis of rotation of said armature, of a field magnet, having a pole piece reduced its entire length on opposite sides of said plane, the reduced portions of the respective pole pieces being on opposite sides of a plane longitudinal of the armature and containing the axis of the winding, at points of approximate maximum effort of said coil, substantially as described.

13. In a magneto-electric generator the combination of a rotatable armature and a coil thereon, and having pole pieces reduced on the same side of a plane perpendicular to the plane of the armature coil, of a field magnet having one of its pole pieces reduced its entire length at both tips, the relative disposition of the armature pole pieces and the field magnet pole pieces being such that the maximum electric effect takes place at intervals which are alternately relatively longer and shorter, substantially as described.

14. In a magneto-electric generator for producing sparks at alternately longer and shorter intervals, magnetic pole pieces, an armature adapted to rotate between said magnetic pole pieces, generating coils carried by said armature, said armature having a body portion and pole pieces substantially at right angles to said body portion, each of said armature pole pieces being cut off on the same side of a plane longitudinal of the armature and at right angles to said armature pole pieces, an amount in angular degrees equal to one-half the difference between said longer and shorter spark intervals, one of said magnetic pole pieces being increased in its arcuate length, an amount equal to that cut from said armature pole pieces, for the purpose described.

15. In a magneto electric generator, a source of magnetic flux, an armature, primary and secondary windings, on said armature, said source of magnetic flux and said armature being adapted to produce three substantial current impulses in said primary winding, one of said impulses being in one direction and the other two in an opposite direction and means for utilizing two of

said impulses to act on said secondary winding for the purpose described.

16. In a magneto electric generator, a source of magnetic flux, an armature having primary and secondary windings thereon, said source of flux and said armature being adapted to produce three substantially current impulses in said primary winding, one of said impulses being in one direction and the other two being in the opposite direction and of unequal strength and means for utilizing the first mentioned impulse and the greater of the two of opposite direction, to act on said secondary winding for the purpose described.

17. In a magneto electric generator, magnet pole pieces, an armature adapted to rotate therebetween, said pole pieces and magnetic material of said armature being arranged asymmetrical with respect to the axis of rotation of said armature, whereby three distinct changes are produced in the magnetic flux traversing said armature, primary and secondary windings on said armature and means for utilizing the first and third of said flux changes to act on said windings for the purpose described.

18. A magneto electric generator a source of magnetic flux, an armature, primary and secondary windings on said armature, said source of magnetic flux and said armature being adapted to produce three substantial current impulses in said primary winding at each rotation of the armature, one of said impulses being in one direction and the other two in an opposite direction, one of said last named two impulses being disposed at alternately longer and shorter intervals relative to the first named impulse which precedes and succeeds the same, and means for utilizing the alternately longer and shorter disposed impulses to act on said secondary winding for the purpose described.

19. In a magneto electric generator, magnetic material disposed to form a path for the magnetic flux, said material comprising fixed parts and a rotatable part, a conductive coil disposed adjacent to said material and adapted to be electrically influenced by changes in said magnetic flux, said changes consisting of one major and two minor impulses, and means for selecting the major and one minor impulse to act on said conductive coil for the purpose described.

20. In a magneto electric generator, magnetic material disposed to form a path for the magnetic flux, said material comprising fixed parts and a rotatable part, a conductive coil disposed adjacent to said material and adapted to be electrically influenced by changes in said magnetic flux, said changes consisting of one major and two minor impulses, and means for selecting the major and the larger of the minor impulses to act on said conductive coil for the purpose described.

21. In a magneto electric generator, the combination of a rotatable armature having a body portion and pole pieces attached thereto, primary and secondary windings on said armature, of field magnet pole pieces, one of said pole pieces being reduced its entire length at both tips and the other magnet pole piece prolonged in excess of ninety degrees, said armature having its opposite pole piece reduced thetir entire length on the same side of the body portion, whereby the rotation of said armature produces a major and two minor current impulses in said primary winding, and means for utilizing the major and one minor impulse at alternately longer and shorter intervals for producing sparks from said secondary, substantially as and for the purpose described.

22. In a magneto electric generator, the combination of a rotatable armature having a primary and a secondary coil thereon, the pole pieces of said armature being reduced from end to end on the same side of a plane perpendicular to the plane of the armature coils, of a field magnet having one of its pole pieces reduced its entire length at both tips, whereby substantial current impulses will be induced in said primary winding at each rotation of the armature at alternately longer and shorter intervals, and means for utilizing said impulses to act on said secondary winding for the purpose described.

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

RICHARD H. CUNNINGHAM.

Witnesses:

JAMES M. WILSON,

FRANK H. MAHER.