Nov. 4, 1947. A. C. WALL 2,430,379

MAGNETO-DISTRIBUTOR

Filed Oct. 17, 1945

Fig. 1

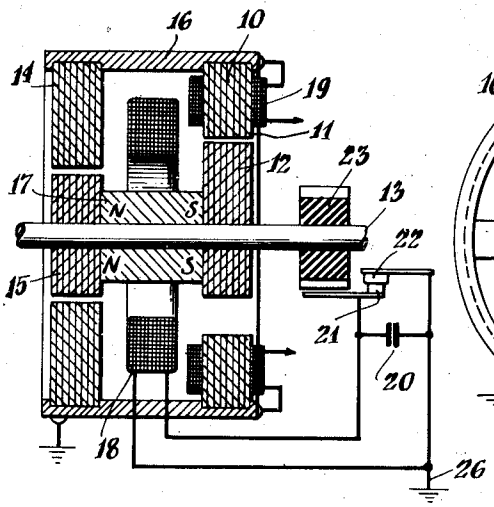


Fig. 2

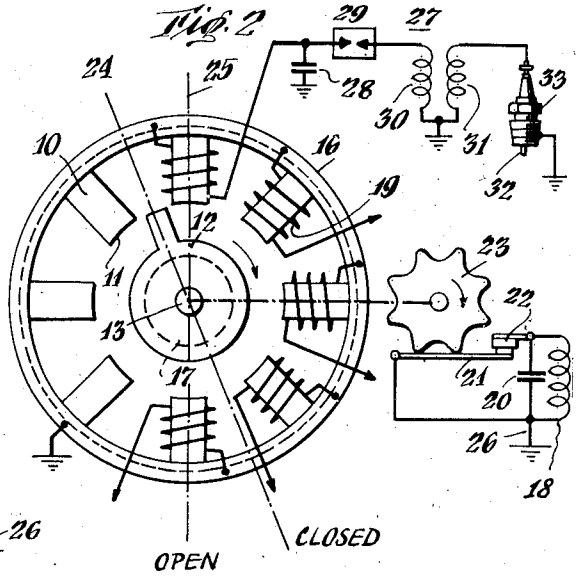


Fig. 3

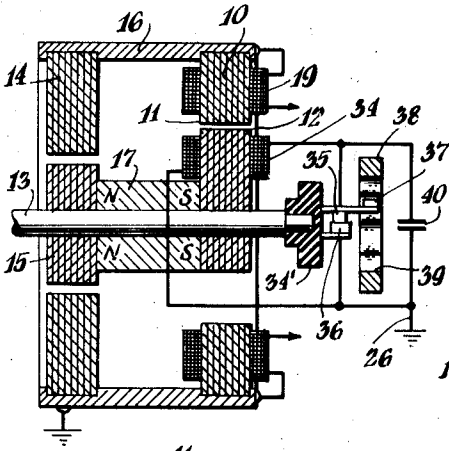


Fig. 4

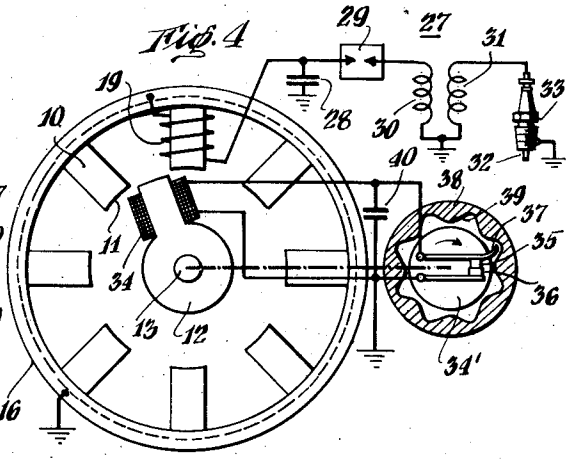


Fig. 5

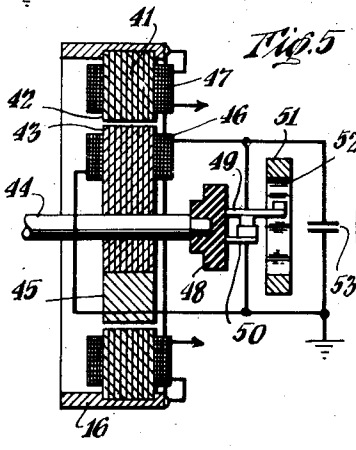
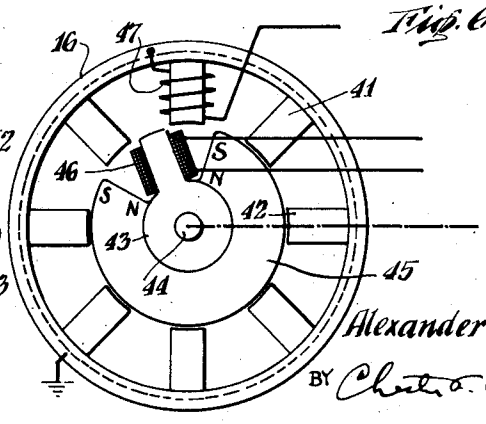


Fig. 6



INVENTOR

Alexander C. Wall

BY Charles A. Carlson

ATTORNEY

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MAGNETO DISTRIBUTOR

Alexander C. Wall, Indianapolis, Ind., assignor to P. R. Mallory & Co., Inc., Indianapolis, Ind., a corporation of Delaware

Application October 17, 1945, Serial No. 622,757

13 Claims. (Cl. 315—218)

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The present invention relates to ignition systems for internal combustion engines having a plurality of cylinders, and, more particularly, to an ignition magneto of novel and improved character having means incorporated therein for the distribution of the ignition voltage pulses to the spark plugs of the several cylinders.

Conventional ignition systems for aircraft engines and similar multicylinder engines generally compromise a magneto in which a primary and a secondary winding are tightly coupled and arranged to be acted upon by a variable magnetic field. The circuit of the primary winding is normally maintained closed and is opened by means of a breaker switch each time when the flux through the said winding tends to be at its maximum, thereby inducing an electrical impulse of high voltage in the secondary winding. These impulses are applied to the spark plugs of the several cylinders by means of the distributor which is essentially a rotary switch operated synchronously with the rotation of the engine.

One of the principal difficulties experienced in connection with the operation of conventional ignition systems of the described character was the unavoidable sparking between the distributor contacts which not only greatly reduced the useful life of the distributor contactor elements but also interfered with the proper and accurate timing of the sparks. This difficulty was particularly serious in airplane engines because at high altitudes both sparking and deterioration of the contacts were greatly increased. Although various suggestions and proposals were made to eliminate the foregoing difficulty, none, as far as is known, of these suggestions and proposals was completely satisfactory and successful.

It is an object of the present invention to provide a complete solution for the outstanding problem.

It is another object of the present invention to provide an ignition system of novel and improved character wherein distribution of the ignition pulses is accomplished by means of rotatable ferromagnetic elements rather than by means of a rotary contactor switch whereby contact difficulties such as sparking, contact wear, and the like, are completely eliminated.

A further object of the invention is the provision of a novel ignition unit in which the generation and the distribution of the ignition pulses is accomplished by means of a unitary structure including a plurality of secondary windings and a single primary winding which is sequentially coupled to the several secondary windings by

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means of rotatable ferromagnetic elements and in the absence of any sliding contactor mechanism.

It is also within the contemplation of the invention to provide a distributorless magneto having novel structural and operational characteristics making it especially adaptable to use in high frequency ignition systems of the type disclosed in my co-pending application Serial No. 549,278, filed August 12, 1944, for improvements in ignition system and apparatus thereof.

Other and further objects and advantages of the present invention will become apparent from the following description, taken in conjunction with the accompanying drawing, in which:

Fig. 1 is a longitudinal sectional view of a magneto embodying the principles of the present invention;

Fig. 2 is a front elevational view of the magneto shown in Fig. 1 and also indicates the circuit organization thereof in connection with a high frequency ignition system;

Fig. 3 is a longitudinal sectional view of a modified magneto embodying the invention;

Fig. 4 is a front elevational view, similar to Fig. 2, of the modification shown in Fig. 3;

Fig. 5 is a longitudinal sectional view of another modification of the invention; and

Fig. 6 is a front elevation, somewhat fragmentary and diagrammatic in character, of the modification shown in Fig. 5.

Referring now more particularly to the drawing, reference numeral 10 denotes a first stator built up from ferromagnetic laminations cut out so as to provide a plurality of pole pieces or teeth 11, generally equal in number to the number of cylinders of the internal combustion engine with which the magneto is operatively associated. The stator cooperates with a single tooth rotor 12 likewise made up of ferromagnetic laminations mounted on a rotatable shaft 13.

In order to provide a substantially closed magnetic circuit of relatively low reluctance, there is also provided a second laminated stator 14 having a circular opening therein in which rotates a second laminated rotor 15 conforming to the shape of the said opening and closely spaced from the inner surface thereof. The second circular rotor 15 is likewise mounted on shaft 13 carrying the first rotor for joint rotation therewith. The two stators 10 and 14 are spacedly held in coaxial relative position by means of a soft iron shell 16, completing the magnetic circuit of the magneto. A magnetic flux is established in the said magnetic circuit by means of a hollow cylindrical permanent magnet 17 mounted around the shaft 13 be-

tween rotors 12 and 15. This magnet is polarized so as to have opposite poles at its axial ends, as this is indicated in Fig. 1.

A stationary primary coil 18 constituted of relatively few turns of wire is spacedly provided around shaft 13 and permanent magnet 17. A secondary coil 19 constituted of many turns of fine wire is mounted around each of the teeth or poles of stator 10. A condenser 20 of suitable capacity and a pair of normally closed contacts 21, 22 are connected across primary coil 18, the said contacts being under the control of a star-shaped cam 23 mounted on and rotatable with shaft 13. This cam is so constructed and arranged that it causes contacts 21, 22 to close when the single tooth of rotor 12 is in one of its intermediate positions between two successive pole pieces of the stator 10, and causes the said contacts to open and to break the circuit of the primary coil each time that the said single tooth of the rotor is exactly aligned with one of the pole pieces. One each of said contact closing and contact opening positions is indicated in Fig. 2 by dot-and-dash lines 24 and 25, respectively. Preferably, one end of the primary coil 18 is grounded to the stator or to the frame of the magneto, as this has been diagrammatically indicated at 26.

One end of each secondary coil 19 is likewise grounded, as this will be best observed in Figure 2, while its other end is connected to a high frequency oscillatory system generally denoted by reference numeral 27. The oscillatory system comprises a condenser 28, a spark or impulse gap 29 and the primary winding 30 of a high voltage transformer. Spark gap 29 is connected between the high voltage terminals of condenser 28 and primary winding 30 and the other terminals of both condenser and winding are grounded. The high voltage end of a secondary coil 19 is connected to the common terminal of condenser 28 and spark gap 29. Primary winding 30 is inductively coupled to a secondary winding 31 one end of which is grounded and the other end of which is connected to center terminal 32 of a spark plug 33, the metal casing of the said plug being grounded in the conventional manner. Of course, a similar oscillatory circuit is provided for each secondary coil 19 of the magneto.

From the foregoing description, the operation of the magneto embodying the invention will be readily understood by those skilled in the art. Permanent magnet 17 will set up a flux in the magnetic circuit constituted by first stator 10, first single tooth rotor 12, ferromagnetic sleeve 16, second circular stator 14 and cooperating second rotor 15. This flux will periodically vary during rotation of shaft 13 and of the two rotors thereon, it will be at its minimum when the single tooth rotor is half way between two of the pole pieces of the stator and it will be at its maximum when the said single tooth rotor is aligned with a pole piece. The cooperation of contacts 21, 22 and star-shaped cam 23 is so adjusted that the said contacts are closed when the single tooth rotor is half way between two successive pole pieces and the said contacts are opened when the said rotor arrives into its aligned position with respect to a pole piece and the flux in the magnetic circuit tends to its maximum. Therefore, each time when the said contacts open, the circuit of the primary coil 18 is likewise opened thereby inducing a high voltage impulse in the corresponding secondary coil 19 by

release of the flux. This voltage surge will break down spark gap 29 and will produce electrical oscillation of relatively high frequency in the oscillatory circuit constituted of condenser 28 and primary winding 30.

Oscillations of identical frequency but of considerably higher voltage will be induced in secondary winding 31 and will produce an intense spark between the center electrode 32 and the grounded electrodes of spark plug 33. Of course, the same mode of operation will occur during further rotational displacement of the single tooth rotor 12 whereby corresponding voltage pulses will be generated in successive secondary coil 19 and such pulses, converted into high voltage high frequency pulses, will produce sparks in the proper sequence in the spark plugs of the internal combustion engine.

It will be noted that the magneto embodying the invention provides numerous important advantages. Thus, the invention combines the magneto and the distributor into a single structural organization whereby space, weight and expense are saved. In addition to this, distribution of the ignition voltage impulses is accomplished without any rotary contacts which are a constant source of trouble and operating difficulties in conventional ignition systems. These advantages are particularly important in aircraft applications where space and weight are very serious considerations and where deterioration of the contactor elements constitutes a serious problem due to the high altitudes at which aircraft is frequently operated. While the magneto of the invention provides particular advantages when employed in combination with high frequency ignition systems of the type disclosed in my co-pending application, S. N. 549,278, it may be employed with similar results in low frequency ignition systems in which the oscillatory circuits 27 are omitted and the high voltage end of each secondary coil 19 is directly connected to the spark plugs.

Figures 3 and 4 illustrate somewhat diagrammatically a modified embodiment of the invention which provides somewhat greater efficiency of operation. It will be noted that this modified embodiment of the invention is closely similar in structure and in its circuit arrangement to the one shown in Figures 1 and 2. Similar reference numerals have been used to denote corresponding parts and for this reason the detailed description of these elements will not be repeated. It will be sufficient to state that this magneto likewise comprises a multi-tooth stator 10 cooperating with a single tooth rotor 12, a second circular stator 14, and a circular rotor 15 therefor, spacedly held by means of a ferromagnetic sleeve 16. A magnetic flux is set up in this circuit by a permanent magnet 17.

The difference between the two forms of the invention resides in the arrangement of the primary coil 34, which in this case is arranged around the single tooth of rotor 12 thereby providing a more efficient magnetic system. Shaft 13 carries an insulative member 34' on which there are mounted a pair of cooperating contacts 35 and 36. An extension 37 of the supporting spring of contact 35 protrudes into cooperating relation with a stationary cam 38 having a star-shaped inner cam surface 39 therein. The springs carrying contacts 35 and 36 are so biased as to tend to open the contacts and are normally restrained from such displacement by the said cam surface 39. A condenser 40 is connected

across primary coil **33** and is rotated therewith, same as contacts **35** and **36**.

The operation of this modified embodiment of the invention is practically identical with that of Figs. 1 and 2. During rotation of shaft **13**, the single tooth rotor will sequentially cooperate with the pole pieces of stator **10** and thereby will periodically vary the magnetic flux through primary coil **34** and also the flux linkage between the said primary coil and the corresponding secondary coil **19**. The cooperation of breaker contacts **35**, **36** and cam **38** is so adjusted that the circuit of the primary coil will be closed each time the single tooth of rotor **12** is half way between two successive pole pieces of the stator and the said contacts will break and will open the circuit of the primary coil each time that the said rotor is accurately aligned with one of the said pole pieces. Therefore, a voltage impulse will be generated in the corresponding secondary coil **19** and this impulse, after being converted into high frequency oscillations by a work circuit **27**, will produce a spark in spark plug **33**. Of course, the same will occur in the successive secondary coils so that ignition sparks will be produced in the several spark plugs in the proper sequence.

Figures 5 and 6 show a further modified embodiment of the invention. This modification provides further simplification of the structure and greatly increased operational efficiency. The magneto comprises a laminated stator **41** having a plurality of pole pieces or teeth **42** corresponding in number to the number of cylinders of the internal combustion engine. This stator cooperates with a laminated single tooth rotor **43** mounted on a shaft **44**. Shaft **44** also carries a permanent magnet **45** having an annular segmentary shape cut out in such a way as to accommodate primary coil **46** around the single tooth of the rotor. Permanent magnet **45** is so magnetized as to form poles of opposite polarity in the radial direction, as this is indicated in Fig. 6. A secondary coil **47** is provided around each pole piece of the stator, each of these coils being electrically associated with a work circuit of the type shown at **27** in Figures 2 and 4. Shaft **44** carries an insulative member **48** upon which are mounted a pair of breaker contacts **49** and **50** connected across primary coil **46**. These contacts are biased to normally maintain the circuit open and are cooperating with stationary cam **51** having a star-shaped cam surface **52** therein. A condenser **53** is connected across primary coil **46** and is rotating therewith.

The operation of this further modification of the invention will be readily understood if it is considered that during rotation of shaft **44** the magnetic flux in the primary coil and in the several secondary coils will be periodically varied between a maximum and a minimum. Minimum flux conditions will prevail each time that the single tooth rotor is half way between two adjoining pole pieces of the stator and maximum flux in the magnetic circuit and maximum flux linkage between the primary and one of the secondary coils will be produced each time that the rotor tooth is accurately aligned with one of the said pole pieces. In the aligned position of the rotor tooth with one of the pole pieces of the stator, the flux passes up through the rotor tooth into the stator and returns through each of the other pole pieces of the stator. This confines the entire magnetic structure to a single plane and also provides a lighter and better balanced unit.

Contacts **49** and **50** are so constructed and arranged with respect to cam surface **52** that the circuit of the primary coil will be closed when the single tooth rotor is half way between two adjoining pole pieces and the said circuit will be opened when the said tooth is aligned with one of the pole pieces. Therefore, a voltage impulse will be sequentially induced in the several secondary coils **47** and such impulses may be directly applied to the corresponding spark plugs or they may be first converted into voltage pulses of a high frequency, as this has been set forth more fully in the foregoing.

Although the present invention has been described in connection with a few preferred embodiments thereof, variations and modifications may be resorted to by those skilled in the art without departing from the principles of the present invention. All of these variations and modifications are considered to be within the true spirit and scope of the invention, as disclosed in the foregoing description and defined by the appended claims.

What is claimed is:

1. In an ignition system for internal combustion engines, the combination which comprises a primary winding, a plurality of secondary windings, means for establishing a magnetic flux through said primary winding, rotatable means for sequentially coupling said secondary windings to the said primary winding, and interrupter means under control of the said rotatable means operable each time when the coupling between the said primary and one of the said secondary windings is the tightest thereby to sequentially induce voltage pulses in the several secondary windings.

2. In an ignition system for multiple cylinder internal combustion engines, the combination which comprises a primary winding, a plurality of secondary windings, means including a permanent magnet for producing a magnetic flux in said primary winding, rotatable ferromagnetic means for periodically varying the flux through said primary winding and to sequentially couple the said winding to each of the secondary windings, and interrupter means operable by said rotatable means for normally maintaining the circuit of the primary winding closed and adapted to open the said circuit whenever the flux linkage between the primary and one of the secondary windings is at its maximum thereby to sequentially induce high voltage pulses in the several secondary windings.

3. In an ignition system for internal combustion engines having a plurality of cylinders, the combination which comprises a primary winding and a circuit therefor, a secondary winding for each of said cylinders, a permanent magnet for producing a magnetic flux in said primary winding, rotatable ferromagnetic elements for cyclically varying during each revolution thereof the flux in said primary winding a number of times equal to that of the number of secondary windings and to sequentially couple the primary winding to each of the secondary windings, switching means for normally maintaining the primary circuit closed and adapted to be actuated to open the said circuit, and an operating mechanism for actuating said switching means to open the primary circuit synchronously with the rotation of said ferromagnetic elements each time when the flux in the primary and in one of the secondary windings is at its maximum thereby to cause the

sequential induction of high voltage pulses in the several secondary windings.

4. In an ignition system for internal combustion engines having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a stator having a pole piece for each of said spark plugs, a secondary coil around each of said pole pieces adapted to be electrically associated with a spark plug, a primary coil in common for said secondary coils, a permanent magnet for producing a magnetic flux in said primary coil, a single-tooth rotor for cyclically varying the flux in said primary coil and to sequentially couple said coil to each of the secondary coils, a breaker switch for normally maintaining the circuit of the primary coil closed and adapted when actuated to break the said circuit, and an actuating mechanism for said switch operable by rotational relative displacement of said stator and said rotor to open said circuit each time the flux in the primary coil and in one of the secondary coils is at its maximum thereby to induce a high voltage pulse in the said secondary coil and the production of sparks in the said spark plugs in the desired sequence.

5. In an ignition system for internal combustion engines having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a ferromagnetic stator having a tooth for each of said spark plugs, a secondary coil around each of said teeth, a primary coil in common for said secondary coils, a permanent magnet for producing a magnetic flux in said primary coil, a single-tooth rotor arranged for sequential cooperation with the teeth of said stator adapted to cyclically vary the flux in the primary coil and the flux linkage between said coil and successive secondary coils between a minimum and a maximum, a normally closed breaker switch connected across the primary coil, an actuating mechanism for said switch operable by rotational relative displacement of said stator and rotor to open said switch each time the flux in the primary coil and in one of the secondary coils is at its maximum thereby to induce a voltage pulse of low frequency in the said secondary coil, and means including a resonant circuit and a spark gap, interposed between each secondary coil and a spark plug, responsive to said pulses and adapted to produce high alternating current potentials of high frequency in said spark plugs in the desired sequence.

6. In an ignition system for internal combustion engines having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a ferromagnetic stator having a tooth for each of said spark plugs, a secondary coil around each of said teeth, a single-tooth rotor arranged on a shaft for sequential cooperation with the teeth of said stator, a hollow cylindrical permanent magnet around said shaft, a primary coil spacedly and concentrically mounted with respect to said magnet, said magnet being adapted to establish a magnetic flux in said primary coil and said rotor being adapted to cyclically vary the flux in the primary coil and the flux linkage between said coil and successive secondary coils between a minimum and a maximum, a normally closed breaker switch connected across the primary coil, and an actuating mechanism for said switch operable by rotational relative displacement of said stator and rotor to open said switch each time the flux in the primary coil and in one of the secondary coils is at its maximum thereby to induce a pulse of relatively high voltage in the said secondary coil and the production of ignition sparks in the spark plugs electrically associated therewith in the desired sequence.

7. In an ignition system having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a first stator having a tooth for each of said spark plugs, a second stator having a circular inner face, a ferromagnetic shell holding said stators in parallel-spaced coaxial position, a first single-tooth rotor adapted to sequentially cooperate with the teeth of said first stator, a second circular rotor adapted to cooperate with said second stator, a shaft for rotating said rotors and thereby to cyclically vary the reluctance of the magnetic circuit formed by said shell and said stators and rotors, a hollow permanent magnet surrounding said shaft and maintaining a magnetic flux in said circuit, a normally short-circuited primary coil around said magnet, a secondary coil around each of the teeth of said first stator and electrically associated with one of the said spark plugs, and interrupter means operable by said shaft each time that the reluctance of the said magnetic circuit is at its minimum thereby to induce a pulse of relatively high voltage in the corresponding secondary coil and to produce ignition sparks in the said spark plugs in the desired sequence.

8. In an ignition system having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a first stator having a tooth for each of said spark plugs, a first single tooth rotor arranged for sequential cooperation with said teeth, ferromagnetic means including a second stator and rotor and a shell constituting with said first stator and rotor a magnetic circuit the reluctance of which is periodically varied during rotation of said rotors, a shaft for rotating said rotors, a permanent magnet for establishing a magnetic flux in said circuit, a stationary primary coil around said shaft, a secondary coil around each of the teeth of said first stator and electrically associated with the respective spark plugs, an electric switch and a condenser connected across said primary coil, and a cam rotatable by said shaft adapted to close said switch each time the reluctance of said magnetic circuit is at a maximum and to open said switch when the reluctance of the said circuit is at a minimum thereby to induce a pulse of relatively high voltage in the corresponding secondary coils and to produce ignition sparks in the said spark plugs in the desired sequence.

9. In an ignition system for internal combustion engines having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a ferromagnetic stator having a tooth for each of said spark plugs, a single-tooth rotor arranged on a shaft for sequential cooperation with the teeth of said stator, ferromagnetic means constituting a magnetic return path for and forming a magnetic circuit with said stator and rotor, a permanent magnet for establishing a magnetic flux in said circuit, said flux being periodically varied between a maximum and a minimum during rotation of said rotor, a secondary coil around each tooth of said stator and electrically associated with the respective spark plugs, a primary coil around the single tooth of said rotor, and switching

means operable by said rotor to close the circuit of said primary coil when said flux is at its minimum and to break the said circuit when said flux and the flux linkage between the primary and one of the secondary coils is at its maximum whereby pulses of relatively high voltage will be sequentially induced in the secondary coils and cause the production of sparks in the spark plugs electrically associated therewith.

10. In an ignition system for internal combustion engines having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a stator having a tooth for each of said spark plugs, a single-tooth rotor arranged on a shaft for sequential cooperation with the teeth of said stator, ferromagnetic means including a second stator and rotor forming a low-reluctance magnetic return path for and constituting a magnetic circuit with said first stator and rotor, a tubular permanent magnet around said shaft and between said rotors for establishing a magnetic flux in said circuit, said flux being periodically varied between a minimum and a maximum a plurality of times for each revolution of said rotors, a secondary coil around each tooth of said stator and electrically associated with a corresponding spark plug, a primary coil around the single tooth of said rotor, a normally closed breaker switch and a condenser connected across said primary coil and rotatable therewith, and a stationary cam member cooperating with said switch to open the same each time when the flux linkage between the primary and one of the secondary windings is at its maximum thereby causing the sequential induction of ignition pulses in said secondary windings.

11. In an ignition system for internal combustion engines having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a stator having a tooth for each of said spark plugs, a single-tooth rotor arranged on a shaft for sequential cooperation with the teeth of said stator, an annular segmentary permanent magnet on said rotor having inner and outer circumferential portions of opposite polarity producing a magnetic flux of periodically varying magnitude through successive teeth of the stator and constituting a magnetic return path therefor with the remainder of the teeth of said stator, a secondary coil around each tooth of said stator and electrically associated with the respective spark plugs, a primary coil around the single tooth of said rotor, and switching means operable by said rotor to close the circuit of said primary coil when said flux is at its minimum and to open the said circuit when said flux and the flux linkage between the primary and one of the secondary coils is at its maximum whereby pulses of relatively high voltage will be sequentially induced in the secondary coils and cause the production of sparks in the spark plugs electrically associated therewith.

12. In an ignition system for internal combustion engines having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a laminated multi-tooth stator, a laminated single-tooth rotor therefor, an annular segmentary permanent magnet on said rotor having inner and outer circumferential portions of opposite polarity, said rotor and said magnet producing a magnetic flux of periodically varying magnitude through successive teeth of the stator and constituting therefor a revolving magnetic return path with the remainder of the teeth of said stator, a secondary coil around each tooth of said stator and electrically associated with a corresponding spark plug, a primary coil around the single tooth of said rotor, a normally closed breaker switch and a condenser connected across said primary coil and rotatable therewith, and a stationary cam plate cooperating with said switch to open the same each time when the flux linkage between the primary and one of the secondary windings is at its maximum thereby causing the sequential induction of ignition pulses in said secondary windings.

13. In a high frequency ignition system for internal combustion engines having a plurality of cylinders and a spark plug for each cylinder, the combination which comprises a primary coil, a plurality of secondary coils, means including a permanent magnet for establishing a magnetic flux in said primary coil, rotatable ferromagnetic elements for periodically varying said flux and to sequentially vary the flux linkage between said primary and the said secondary coils between a maximum and a minimum, interrupter means for said primary coil operable by said elements each time when said flux and said flux linkage are at their maximum thereby to induce a pulse of low frequency in the corresponding secondary coil, and means including a resonant circuit and an impulse gap interposed between each secondary coil and its associated spark plug responsive to said pulses and adapted to produce high alternating current ignition potentials of high frequency in said spark plugs in the desired sequence.

ALEXANDER C. WALL.

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The following references are of record in the file of this patent:

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