Sept. 15, 1931. H. P. SPARKES 1,823,217

IGNITER

Filed June 29, 1929 2 Sheets-Sheet 1

Fig. 1.

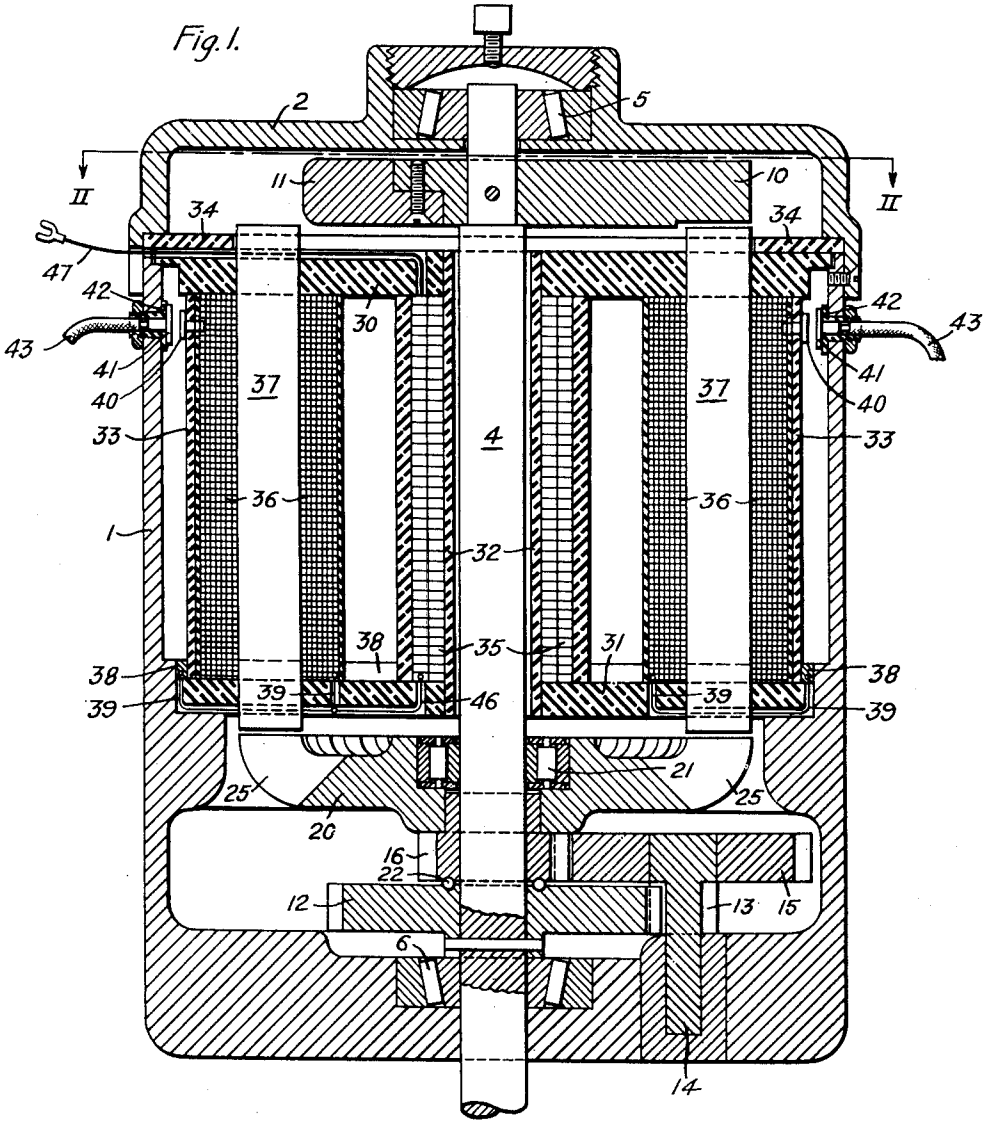
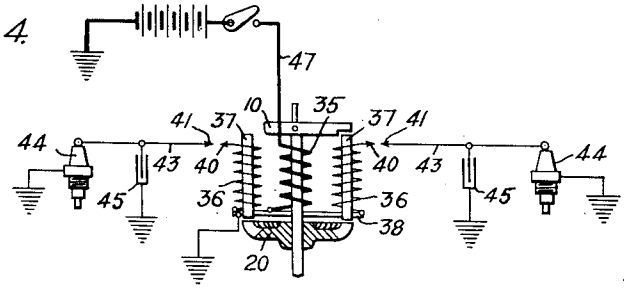


Fig. 4.



INVENTOR

Harry P. Sparkes

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Fig. 2.

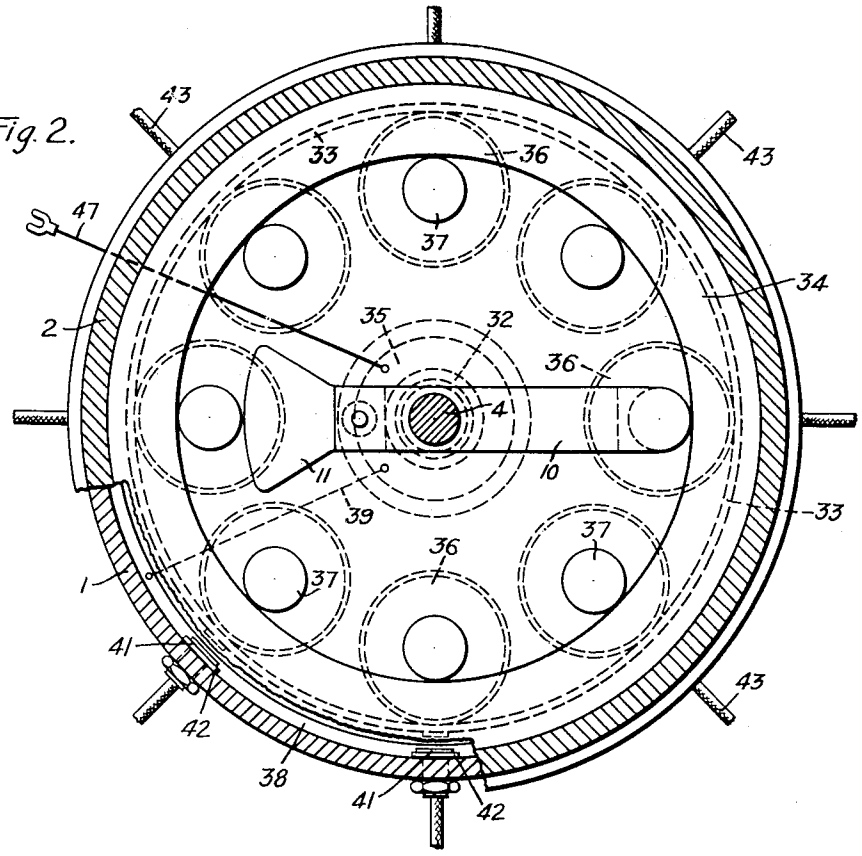
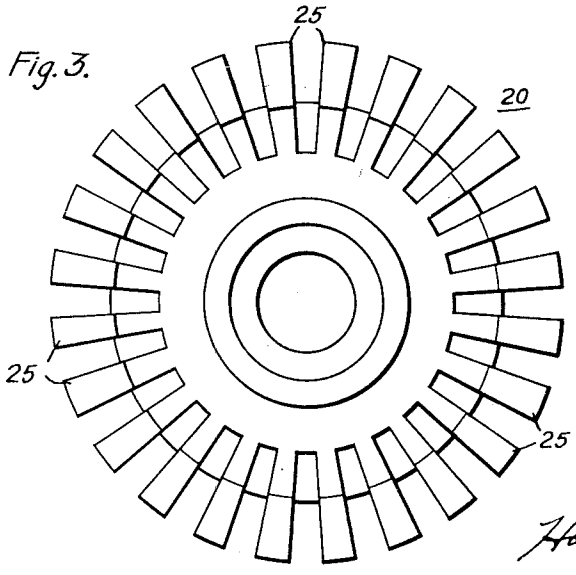


Fig. 3.



INVENTOR

Harry P. Sparkes

Patented Sept. 15, 1931

1,823,217

UNITED STATES PATENT OFFICE

HARRY P. SPARKES, OF PITTSBURGH, PENNSYLVANIA

IGNITER

Application filed June 29, 1929. Serial No. 374,687.

My invention relates to electrical systems and more specifically to ignition systems for engines of the internal-combustion type.

Although my invention is applicable to all types of internal-combustion engines utilizing an electrical discharge or spark for igniting or exploding an explosive or inflammable mixture, for the purpose of facilitating the present disclosure I will describe a preferred embodiment of my invention in its application, specifically, to the type of engine usually embodied in automobiles. It will be obvious, in the light of the following matter, that my invention is peculiarly well adapted for engines of the air-craft types as well as rotary engines of the reciprocating and turbine types, but is described in connection with automotive engines purely by way of example.

The usual type of ignition circuit now employed embodies an induction coil having a primary winding connected across a low-voltage source and having an interrupter or breaker in series therewith to alternately complete and break the primary circuit in accordance with the speed of the engine. The secondary winding of the coil has a substantially greater number of turns than the primary and is adapted to be connected in series with the spark plugs of the engine. A distributor, operated by the engine, delivers the high-voltage current of the secondary winding to the spark plugs in a predetermined sequence.

Many expedients have been resorted to in attempts to increase the intensity of the discharge at the spark plugs, and the necessity for such expedients becomes increasingly important in view of the present tendency toward internal-combustion engines having high-compression high-speed characteristics. These expedients, for example, include the provision of auxiliary spark gaps disposed in the high-tension circuit in various positions and relations, and the provision of condensers in various parts of the system to improve the power factor thereof.

It is apparent to those skilled in this art, that present types of ignition systems leave much to be desired. They are inherently inefficient electrically, in view of the high value of inductance of the induction coil, and attempts to improve this efficiency by correcting the power factor have proved too unreliable and complex to be suitable for production purposes. Further, the distributor and breaker assembly are very complicated mechanically and constitute a complex and expensive production assembly. On the other hand, the breaker contacts are unreliable in operation because of their tendency to corrode or pit, and must be given frequent periodic attention.

Further, the mechanisms now employed for advancing and retarding the spark, i. e., for determining the time of the explosion with reference to the position of the piston, usually involve a complicated series of mechanical linkages controlled manually, or means embodying a centrifugal device for advancing the spark automatically. Either type is inherently unreliable but the manually operable type is particularly objectionable because it involves a personal element. This is particularly true in the case of aviation engines where it is customary to start the engine and permit it to warm-up with the spark retarded. A retarded spark, of course, reduces the effective power of the engine, and a considerable number of serious accidents have been directly traceable to the failure of the operator to advance the spark before attempting to take-off.

I have determined, as a result of experimental research, that the single induction coil, employed in conjunction with present-day multi-cylinder engines, actually and definitely limits the possible engine speed obtainable. The valve of inductance in a coil now commonly and widely used is approximately 30 henrys. With such a high value, and in view of the number of high-tension impulses that must be delivered to the spark-plug circuit at high engine speeds, it is obvious that the flux in the iron core of the coil must be successively built-up and dissipated with great rapidity, and the maximum rapidity is definitely limited by the magnetic characteristics of the core.

Multi-cylinder automotive and aviation

engines of present-day design using a single ignition coil rarely attain a speed in excess of 3500 R. P. M. The engines may be operated at higher speeds but at approximately 3700 R. P. M. misfiring becomes noticeable and the efficiency of the engine is seriously impaired.

This fact is generally recognized by the industry and attempts have been made to obviate it, usually by employing a plurality of induction coils or magnetos supplying the spark plugs of separate cylinders or groups of cylinders. For example, a well known make of automobile of the eight cylinder type employs two separate ignition systems each supplying the spark plugs of four of the cylinders. It is also recognized by the industry that such an expedient is a make-shift, but up to the present time it is the only answer to the problem.

The misfiring of the engines at high speeds may be readily explained. Each time the interrupter in the primary circuit closes, the primary coil is energized and a flux is built up in the iron core of the coil. When the interrupter opens, the break-down of this flux generates an impulse in the secondary winding. The impulse is of damped oscillatory character and although the first few oscillations are effective to cause a discharge across the points of the spark plug, a definite period of time is required before the oscillating wave train approximates zero. If the oscillations have not reached zero by the time the next succeeding impulse is generated, the second impulse and the remnant of the first interfere, and distort the character of the second impulse to such an extent that it is ineffective to operatively energize the spark plug circuit.

In a well known type of eight-cylinder automobile engine, I have, by the use of one aspect of my invention, readily attained engine speeds of the order of 6,000 R. P. M., thereby greatly increasing the acceleration of the engine and the possible speed of the vehicle with which it is associated. The maximum speed is, in fact, limited only by the precision of balance and the mechanical stress characteristics of the moving parts of the engine, and the capacity of the in-take and exhaust manifolds.

An object of my invention, therefore, is the provision of a simplified ignition system for internal combustion engines whereby engine speeds greatly in excess of present speeds are made possible, and each fuel charge is fired efficiently.

A further object of my invention is the provision in an ignition system of means for generating high-frequency high-tension oscilllatory impulses, including means for preventing interference and distortion between succeeding impulses.

Another object of my invention is the provision of an improved impulse generator for supplying a series of high-frequency impulses to a plurality of circuits in a predetermined sequence.

Another object of my invention is the provision of an improved high-frequency ignition generator embodying means for increasing the out-put voltage and frequency in accordance with the engine speed, and for automatically advancing the ignition "timing" as the engine speed increases.

A further object of my invention is the provision of an ignition system for an internal-combustion engine which is unusually simple in design and wherein the use of moving electrical contacts, and other elements which render present systems unreliable, is avoided.

Referring to the drawings:

Figure 1 is a view in vertical section of a generator or igniter constructed in accordance with my invention;

Fig. 2 is a plan view of the mechanism shown in Fig. 1, the cover being removed,

Fig. 3 is a plan view of one of the elements embodied in Fig. 1, and

Fig. 4 is a diagrammatic illustration of the application of my invention to an internal combustion engine.

Referring more specifically to the drawings, there is illustrated in Figs. 1, 2 and 3 an igniter, or high-frequency impulse generator, constituting a preferred embodiment of my invention. A casing 1 of insulating material, or non-magnetic metallic material, which may be molded, as shown, having a cover 2 for association therewith, is provided with aligned apertures positioned, respectively, in the bottom and cover for the reception of a rotatable shaft 4 of magnetic material. Suitable roller bearing means, 5 and 6, may be disposed in the apertures, as shown, to aid the free rotation of the shaft.

Adjacent to the upper end of the shaft, and rigidly secured thereto, I provide an elongated member 10 of magnetic material having a weight 11 secured thereto for counterbalancing said elongated member with respect to the axis of the rotatable shaft.

The lower end of the shaft 4 projects through the bottom of the casing for engagement with a rotating part of the engine (not shown) with which the device is to be associated. I prefer, in the present embodiment, to so proportion the casing and shaft that my device may be readily substituted for the distributor and timer assembly now in common use on automotive engines.

With such a substitution, in view of existing substantially universal practice, the shaft will be rotated in accordance with the speed of the engine, and, specifically, it will rotate at half the value of engine speed.

A gear wheel 12 may be keyed or otherwise secured adjacent the lower end of the shaft 4 within the casing for cooperation with a

pinion 13 secured to a shaft 14 journalled in the base of the casing. A gear 15 also secured to said shaft 14 and of considerably larger diameter than said pinion, is disposed for cooperation with a pinion 16 rigidly secured to a plate 20. The pinion and plate are freely rotatable with respect to said shaft and a roller bearing 21 may be interposed between the plate and shaft to facilitate the relative rotation thereof. A bearing means 22 may also be provided between the pinion 16 and gear 12, as shown, to reduce the friction therebetween.

With the assembly thus far described it is apparent that the shaft and elongated magnetic element or armature 10 will rotate at half engine speed, and the plate will rotate much faster with respect thereto by reason of the gearing interposed therebetween. In a preferred embodiment of my invention I prefer to employ gearing of such a ratio that the plate will rotate eight times faster than the shaft 4.

Referring to Fig. 3, wherein the plate is shown in plan view, a plurality of radial peripheral slots, twenty-four in the present instance are provided. The purpose of these slots, and the resulting projecting portions or teeth 25 therebetween, will be described hereinafter.

A pair of partitions 30 and 31 may be mounted in spaced relation within the casing and are disposed, respectively, below the plane of the elongated armature element 10 and just above the plane of the plate 20. The partitions are apertured axially to receive a sleeve 32 which is of a suitable diameter to permit unrestrained rotation of the shaft 4 therein, and the partitions are maintained in spaced relation by a cylindrical wall 33 cooperating therewith and adjacent to the peripheral edges thereof. Preferably the partitions 30, 31, the sleeve 32, and the wall 33 are secured together, to facilitate the insertion and removal thereof as a unit, for a purpose hereinafter described.

Surrounding said sleeve 32 I dispose a winding 35 which, as hereinafter described, constitutes a primary or exciting winding, and within the annular space defined by said winding, the cylindrical wall 33 and said partitions 30 and 31, I provide a plurality of windings 36 equally spaced circumferentially with respect to said shaft, and corresponding in number with the number of cylinders, or spark-plugs, with which the device is to be associated.

Each of these windings is provided with a core 37 of magnetic material having the ends thereof projecting through said partitions 30 and 31. The length of the cores is such that the upper ends thereof are as close to the plane defined by the lower face of the rotatable armature as mechanical safety will permit, and the lower ends thereof are in a similar relation to the plane defined by the upper face of the plate 20.

It will be apparent that with this construction, the shaft 4, armature 10, core 37 and plate 20 define a substantially complete magnetic circuit, and by movement of the armature over the exposed upper ends of the cores 37 a magnetic circuit is established through said cores in sequence.

As above noted, the partitions 30, 31 and the cylindrical walls 32 and 33 are preferably assembled as a unit and, in order to increase the insulation of the windings 36 at the high frequencies encountered, the space surrounding them may be filled with oil, paraffine, or the like. The entire coil assembly may then readily be removed from the casing for replacement, if necessary. A retaining ring 34 of annular shape may be employed to maintain the coil assembly in proper position in the casing 1.

An annular electrically conducting ring 38 may be secured to the coil assembly adjacent to the partition 31, as indicated, and serves as a common "ground" connection for the windings 35 and 36, as hereinafter described.

The electrical connections to the various elements are made as follows. A lead 39 is brought out at the lower end of each of the windings 36 and extended through a suitable aperture in the lower partition 31. A plurality of radial slots may be provided in the under face of partition 31 extending from said aperture to the periphery of the partition adjacent to the ground ring 38. The leads 39 may then be disposed in said slots and the terminals thereof may be electrically connected to said ground ring.

If the casing 1 is of conducting material, the ground ring may be electrically connected thereto, but if a casing of insulating material is employed an additional lead must be extended from the ring through the wall of the casing to a suitable ground connection.

Adjacent to the upper edge of the annular partition 33, a plurality of terminals 40 are provided each comprising a conducting surface or plate of substantial area on the outer face of the partition, and means on the inner face of the partition for securing thereto the lead from the upper end of the winding 36.

A plurality of terminals, indicated generally as 41, extend through the casing 1 for cooperation with the coil terminals 40. Each of the terminals 41 comprises a high-potential insulating bushing 42 having, at the inner end thereof a conducting surface or plate of substantial area adjacent to, but spaced from, the corresponding conducting area of said coil terminal 40. The purpose of this terminal arrangement is specified in detail hereinafter.

High-tension leads 43 may be electrically

connected, within the bushing, to the conducting surface and extended from the bushing to the spark-plug device 44 (Fig. 4).

A condenser 45 (Fig. 4), having a capacitance of such a value that the spark-plug circuit is tuned to a frequency proportional to the engine speed, may be connected in parallel with the spark-plug 44 for improving the power-factor of the circuit.

The primary winding 35 may have one terminal thereof connected to the ground-ring 38 by a lead 46 in a manner similar to the connection of the lower terminals of the windings 36. The upper terminal of the primary winding may be connected to a lead 47 which is embedded in the upper face of partition 30 and extended through the side of the casing 1 to the ungrounded terminal of the conventional storage battery, or other desired source of potential, as indicated in Fig. 4.

Assuming that the various elements of the igniter are in the position shown in Fig. 1, and the electrical connections indicated in Fig. 4 are completed, it is apparent that the energization of the primary winding 35 will establish a magnetic flux in the magnetic circuit comprising the shaft 4, arm 10, core 37 and slotted plate 20, and a resulting electromotive force will be generated in the secondary winding 36. It is to be understood, of course, that if the shaft 4 constitutes a permanent magnet, the primary winding 35 may be omitted.

Assuming, by way of example, that the engine with which the device is associated is operating at a speed of 4000 R. P. M., the shaft and armature will be rotated at a speed of 2000 R. P. M. In other words, in the case of an eight-cylinder four-cycle engine, only half of the cylinders, or four, are exploded each revolution of the engine.

Neglecting for the moment the teeth on the plate 20, as the armature approaches and passes over each of the cores 37 a flux is generated therein which starts from zero, approaches a maximum as the armature registers with the core, and decreases again to zero as the armature passes on.

While the armature 10 is passing over one of the cores 37, however, or during 1/8 of a revolution, the plate 20 rotates 8 times that distance, or one revolution. Since there are 24 teeth on the plate 20, as the armature travels 1/8 of a revolution the permeability of the magnetic circuit is altered successively 24 times resulting in 24 oscillations in the secondary winding.

The frequency of these oscillations, at 4,000 R. P. M. engine speed, will be

$$\frac{4000\times 8\times 24}{2\times 60}=6{,}400$$

oscillations per sec. This may be made materially higher than the frequency encountered in present systems employing a single coil, and results in improved sparking characteristics at the plug. On the other hand, in view of the fact that the secondary windings are separately energized, there is no possibility of interference between succeeding impulses.

It is also pointed out, that, with the construction described, the oscillations are forced, or undamped, as distinguished from the damped oscillations of the conventional type of ignition coil, and the resulting high-tension current has an alternating wave form, the alternations of which increase from a small amplitude, or zero, to a maximum value when the arm 10 registers with the core 37, and decrease thereafter to a zero value.

It is vital, in internal combustion engine practice, that the occurrence of the spark at the spark-plug be accurately and sharply timed with respect to the engine compression cycle. In the present construction accurate timing is afforded and the timing is automatically advanced, as the engine speed is increased, by means of the spaced conducting surfaces of the terminals 40 and 41. These surfaces are so spaced that a discharge between them to energize the spark-plug circuit, cannot take place until the potential generated in the winding 36 reaches a predetermined magnitude. By properly spacing of the surfaces, therefore, only a portion of the generated voltage oscillation train will be effective to energize the spark-plug circuit

The spaced surfaces are of substantial area, as above pointed out, and they constitute, in effect, condenser plates the capacitance thereof serving to correct the low power-factor character of the secondary circuit.

Further, as the engine speed increases, the frequency and magnitude of the voltage generated in the secondary windings also increases, so that the break-down across the condenser surfaces will occur sooner than at lower speeds. This is a very desirable feature since it affords an automatic advance in the spark timing as the engine speed increases, and wholly obviates the necessity for mechanical means to accomplish this function. On the other hand, at higher engine speeds, the number of impulses delivered to the spark-plug will be proportionally greater than at lower speeds, resulting in a more efficient combustion.

A further function of the conducting areas of the terminals 40 and 41, is that the necessity for a solid electrical connection between the secondary winding 36 and the spark-plug lead 43 is avoided, thereby facilitating the assembly of the unit and permitting the ready removal of the windings as a unit, as previously indicated. When the gap between the conducting areas has once been adjusted, there is very little possibility of the adjustment being accidentally altered, and, on the

other hand, the size of the areas is such that they will withstand long periods of usage without pitting, and have sufficient thermal capacity to prevent injury due to heating.

It is apparent, from the foregoing description that I have provided an igniter which is unusually simple in construction and reliable in operation; that avoids the use of and necessity for delicate moving parts and electrical contacts; that may be accurately and readily timed with respect to the engine cycle and permitting an automatic advance of the timing as the engine speed increases; and which is inherently efficient electrically and delivers a high-tension high-frequency current at a favorable power factor, to the engine spark-plug device.

Various modifications may be made in my invention without departing from the spirit and scope thereof and I desire therefore that only such limitations shall be placed thereon as are imposed by the prior art and set forth in the appended claims.

I claim as my invention:

1. In an ignition device, the combination with a winding for supplying an oscillating current to a spark-device and a magnetic core for said winding, of means cooperating with said core to periodically complete a magnetic circuit therethrough, and means for varying the reluctance of said circuit during said period.

2. Means for generating a high-frequency oscillating current of varying amplitude in a winding comprising a magnetic core for said winding, magnetizable means for cooperation with said core, means for producing relative movement between said core and magnetizable means for periodically generating an oscillating magnetic flux in said core, and means controlled by said movement for rapidly varying said flux during said periods.

3. An ignition device for an internal combustion engine comprising in combination with a winding for supplying a spark-plug device, of a magnetic core for said winding, means for generating an oscillating magnetic flux in said core having a frequency in accordance with the speed of said engine, and magnetic means controlled thereby and cooperating with said core for increasing the frequency of said flux in accordance with a multiple of the speed of said engine.

4. A high-frequency oscillation generator comprising a movable magnetizable element and means for producing a flux therein, a winding having a magnetic core disposed adjacent the path of movement of said element, and means associated with said core and element, and controlled by said element, for intermittently substantially completing a magnetic circuit through said core and element.

5. In combination with a spark-device of an internal combustion engine, means for generating a forced oscillating electromotive force for energizing said device having a variable frequency proportional to the speed of said engine, means for connecting the output of said generator to said spark-device including means responsive to a predetermined electromotive force for effectively energizing said spark-device and for advancing the time of such energization with respect to the cycle of said engine as the speed thereof increases.

6. In an ignition device, the combination with a winding for supplying an oscillating current to a spark-device and a magnetic core for said winding, of means cooperating with said core to periodically substantially complete a magnetic circuit therethrough, said means including means for varying the magnetic reluctance of said circuit during said period.

7. In an ignition device, the combination with a winding for supplying an oscillating current to a spark-device and a magnetic core for said winding, of means cooperating with said core to periodically substantially complete a magnetic circuit therethrough, said means including means for varying the magnetic reluctance of said circuit during said period between predetermined limits at a high periodicity compared to the periodicity of said first mentioned means.

8. In an ignition device, the combination with a winding, and a core of magnetic material therefor, of means including a movable member of magnetic material and means for moving it to periodically cooperate with said core to generate a flux therein, said means including means for periodically varying the magnitude of said flux during the period of movement of said movable member.

9. In an ignition device, the combination with a winding, and a core of magnetic material therefor, of means including a movable member of magnetic material and means for moving it to periodically cooperate with said core to generate a flux therein, said means including means for periodically varying the magnitude of said flux at a periodicity proportional to the speed of movement of said movable member.

10. An electric generator comprising a winding and a core of magnetic material therefor, means for periodically generating a magnetic flux in said core comprising a magnetized member movable periodically with reference to said core and adjacent thereto, and means controlled by the movement of said magnetized member for varying the magnitude of said flux between predetermined limits at a high periodicity compared to the movement of said magnetized member.

11. An electric generator comprising a winding and a core of magnetic material

therefor, means for periodically generating a magnetic flux in said core comprising a magnetized member movable periodically with reference to said core and adjacent one end thereof, and means comprising an element having alternate sections of different magnetic permeability cooperating with the other end of said core and movable with respect thereto, and means for moving said element in accordance with the movement of said magnetized member.

In testimony whereof, I have hereunto subscribed my name this twenty-eight day of June, 1929.

HARRY P. SPARKES.