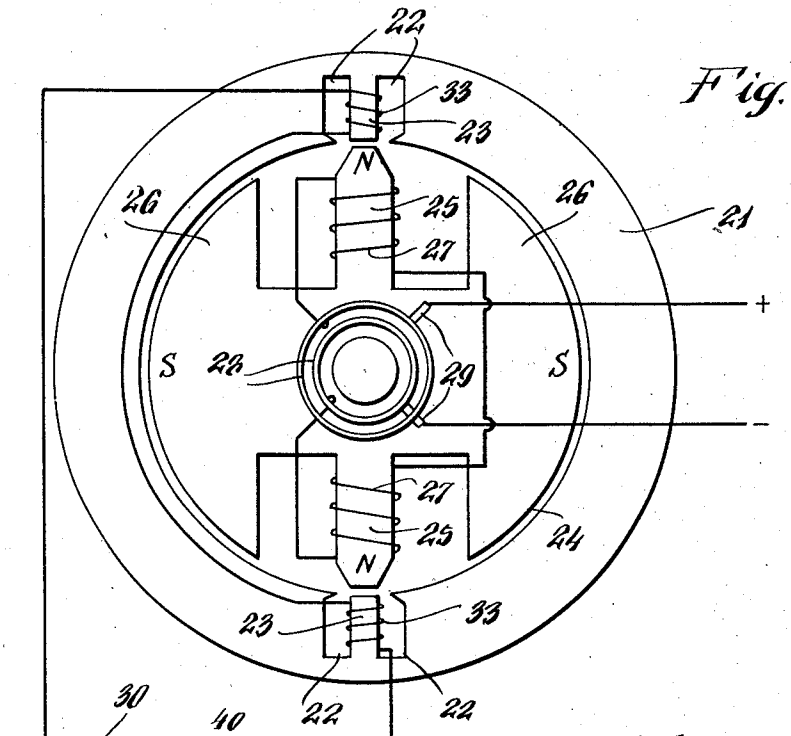
Sept. 28, 1948. D. I. BOHN 2,450,404

IGNITION SYSTEM

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Fig. 1.



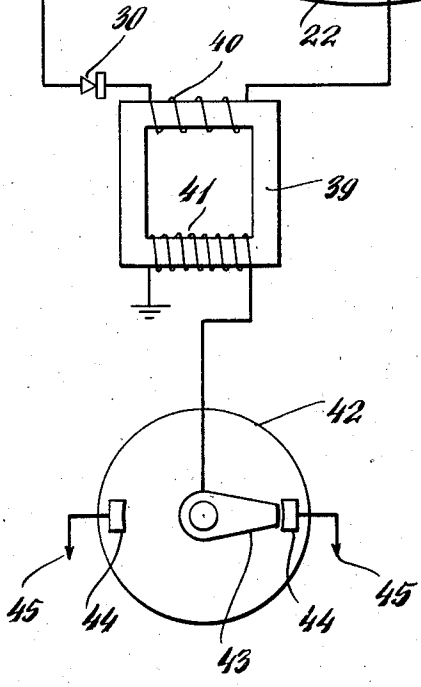


Fig. 2.

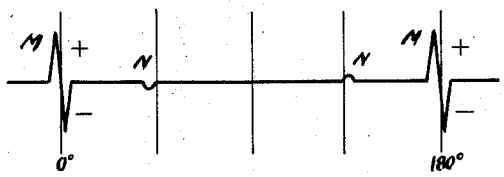
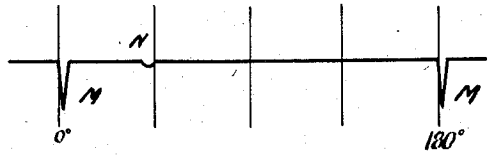


Fig. 3.



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Fig. 4.

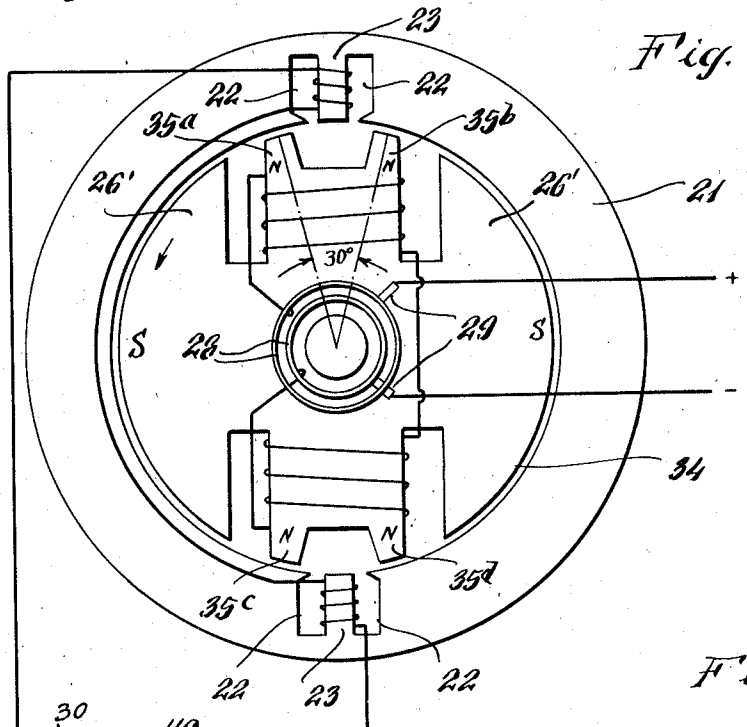
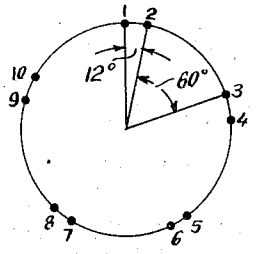
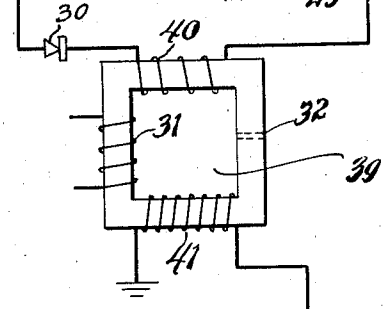


Fig. 6.





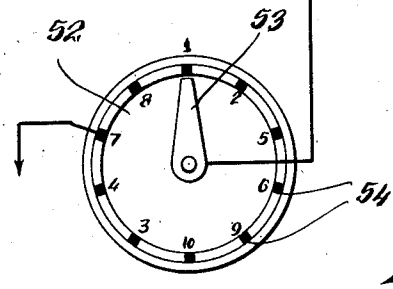
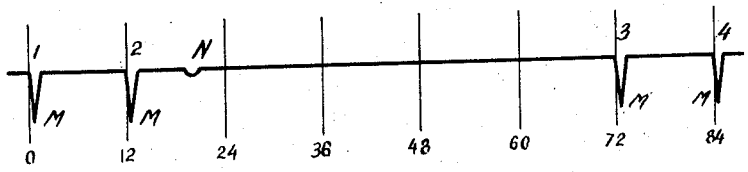


Fig. 5.



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Fig. 8.

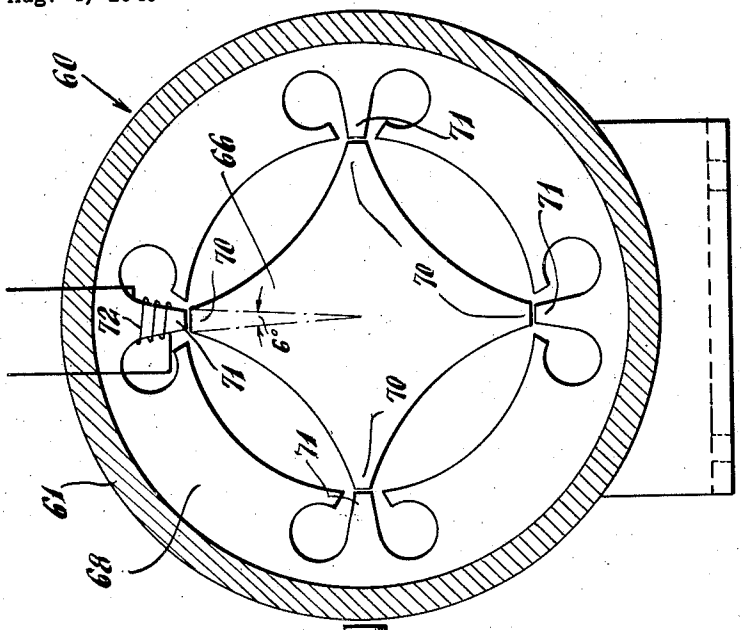
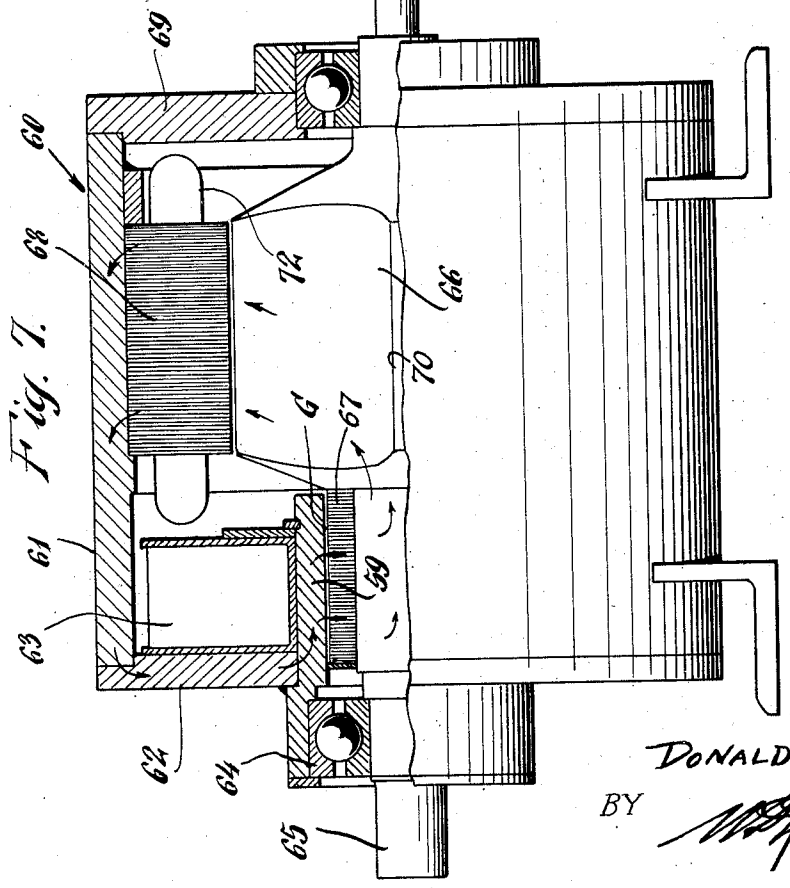


Fig. 7.



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2,450,404

IGNITION SYSTEM

Donald I. Bohn, Pittsburgh, Pa.

Application August 4, 1945, Serial No. 608,881

8 Claims. (Cl. 315—218)

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This invention relates to electrical ignition systems and particularly to such systems employing sparking devices and a generator rotor for supplying the sparking impulses.

The object of the invention is to provide a simple, efficient system dispensing with current breaking contacts and giving a single uni-polar discharge for each ignition sparking.

Further objects of the invention particularly in the special features of the generator, step-up transformer and distributor combination will appear from the following specification taken in connection with the accompanying drawings, in which

Fig. 1 is a diagrammatic showing of an ignition system embodying the invention;

Figs. 2 and 3 are typical oscillograph sketches illustrating the potential impulses developed by the system;

Fig. 4 is a diagrammatic showing of a modified system;

Fig. 5 is a typical oscillograph record of the potential impulses characteristic of the system of Fig. 4;

Fig. 6 is a diagram for an engine of the system of Figs. 4 and 5; and

Figs. 7 and 8 are longitudinal and transverse views respectively of a generator for a further modified system of this invention.

Referring to Figs. 1 to 3, the potential generator consists of a stator 21 having four slots 22 resulting in two teeth 23, these being 180° apart. A rotor 24 made of solid steel is provided with narrowed poles 25 and field poles of long circumferential length 26. Two windings 27 are connected to two slip rings 28 on which brushes 29 ride.

The two windings 27 on poles 25 are connected so as to make the poles 25 of the same polarity. The two windings 33 on stator poles 23 are connected directly in series in such a way that their voltages are always additive.

The output of these two stator windings 33 is connected to a transformer 39 of conventional, laminted construction, carrying a primary winding 40. This transformer 39 also has a secondary winding 41 consisting of many times the turns comprising primary winding 40. One end of winding 41 is grounded, thereby connecting it to the shell of the spark plugs on the engine. The other terminal of winding 41 goes to the distributor 42 and connects to the rotating distributor arm 43. When this arm rotates, it goes close to stationary terminals 44 but does not touch them. The two stationary terminals 44 are

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each connected to the center electrode of two spark plugs represented as 45.

This system is adapted, for instance, to a two cylinder, two cycle, alternate firing gas engine and for this engine the ignition generator rotor would revolve at engine speed and the distributor arm 43 would also revolve at engine speed.

When the device is placed in operation, it will be observed from the oscillograph record (Fig. 2) that, whenever narrow poles 25 go by stator teeth 23, a sine wave of potential of peaked or steep wave front form is generated (ignoring the rectifier 30) but, since these poles are always of the same polarity, such generation will always have the first half cycle of each impulse M of the same polarity. In addition to the complete sine waves M, always starting with the same polarity, which are generated when poles 25 go by teeth 23, there will be additional generation occurring between these times when poles 26 go by teeth 23. Since, however, the flux density from poles 26 across the air gap to teeth 23 is but a fraction of that which exists when poles 25 go past teeth 23, the voltage generated by poles 26 will be but a small percentage as great as that generated by poles 25. This low generated voltage is simply negligible as there is no circuit provided for its period of generation at the distributor. The generator thus provides solely through relative rotation of its rotor and stator a potential output consisting of full wave, steep front voltage impulses of the same starting polarity at intervals corresponding to the firing periods of the engine with a period of substantially zero potential generation between successive impulses.

The oscillogram (Fig. 2) shows quite clearly the current flow in the main lead to the distributor with rectifier 30 not connected in the circuit. The effect of the return flux on poles 26 is indicated by the very small voltages N generated of an opposite polarity in the "dead" period between the main impulses.

Below Fig. 2 another oscillogram (Fig. 3) shows current in the main lead to the distributor with rectifier 30 inserted in the ignition generator output circuit as indicated. The polarities are so chosen that, let us say, the plus half cycles are not allowed to exist since rectifier 30 blocks such flow of current. Therefore, the only impulses which can exist in this circuit are the two main negative half cycle impulses occurring 180° apart and the minor impulse N of a negative polarity which occurs between these two main impulses.

The net effect of this system, therefore, is to provide accurately timed impulses in the high

tension circuit, each impulse being of the same polarity and of only one half cycle length.

The system thus comprises an impulse generator with a rotor designed as shown having alternate poles of very short and very long circumferential lengths so that stator voltages induced by the former provide the desired ignition voltage and current, whereas the necessarily obtained impulses from the poles of long circumferential length generate such an extremely low voltage that they are not employed and cause no harm or improper operation.

A further advantage of the system is the employment of a rectifier in the impulse generator output circuit to cut out one-half of each full sine wave which is generated by the impulse generator. In this way a desirable, fixed polarity is always supplied to the spark plugs at properly timed intervals, and the excessive spark plug erosion resulting from a full sine wave of current at the plugs is eliminated.

There are various modifications of this system which can be made using the same principles and will permit the equipment to be used on engines of some particular construction, such as those which do not have equal intervals between firing periods.

An example is illustrated in the system of Figs. 4 and 5 which show the principle applied to a specific engine of a 10 cylinder, 2-cycle, V-type, having a 5 throw crankshaft with the two banks of five cylinders each arranged at 60° to each other. Since the crankshaft throws are 72° apart and the cylinders are at 60°, this means that there will be alternate pairs of firing cylinders, with 12° between two impulses and then a 60° period before the next similar pair fires at 12° apart. This results in the engine diagram as shown in Fig. 6.

This system is similar to that of Figs. 1 to 3 except that four narrow firing poles **35a**, **35b**, **35c** and **35d**, are provided as shown on field rotor **34**, all of them of the same polarity, two return flux poles **26'** of long circumferential length being provided.

With the two adjacent firing poles spaced at 30° and the two pairs of firing poles at 180°, the firing poles will provide properly timed impulses when this generator (Fig. 4) is run at two and a half times engine speed.

The distributor **52** has arm **53** and ten equally spaced terminals **54** for connection to the spark plugs, thus giving 36° between each stationary sector. The distributor **52** will run at three times engine speed and with the cylinders firing in numbered sequences as shown on the engine diagram (Fig. 6) the sectors would be in order and numbered and connected as shown on the distributor (Fig. 4).

Fig. 5 shows an oscillograph of current output from transformer **39** to the distributor arm **53** giving perfectly timed uni-polar impulses M of one-half cycle each at the distributor, with the exception of a very small impulse N occurring at about 20° from the nearest impulse M. This minor impulse N results from the entrance of the return flux pole **26'** into the stator tooth field; it is of negligible amount and occurs at a dead space on the distributor and so is of no consequence.

The effective ignition is concentrated in the series of properly timed unidirectional half-cycle impulses, one for each sparking period.

The system is thus capable of giving a simple powerful spark with precise control of the intervals and without breaker points or other complications involved in the usual magneto or battery-operated ignition systems.

Modifications and adaptations may be resorted to in the fitting of the system to different engines and the generator may be varied in its structure and operation, for instance to provide any desired number of cooperating rotor and stator elements. In Figs. 7 and 8 the generator **60** will give firing impulse at equal intervals four times per revolution. It could have the poles spaced to fire with unequal intervals, such as 30° and 150°, for instance, by changing the rotor design and using only two stator coils. And other firing intervals could be provided as desired.

In the structure shown the main stator frame **61** is made from a cylinder; the left bell **62** is a welded assembly mechanically supporting the stationary field coil **63** mounted as shown, and providing a path for magnetic flux across air gap G into the rotor proper as indicated by arrows. It also houses the bearing **64** carrying the main shaft **65** which preferably is in one piece with the rotor **66**. Laminated circular punchings **67** are pressed onto an enlarged portion of shaft **65** and rotor **66** and so machined as to provide the small gap G between their circumference and the inside bore of the tubular portion **59** of the bell **62**. A laminated stator **68** is fitted tightly in stator frame **61** and a small air gap is provided between rotor **66** and stator **68**, as shown. The right hand bell **69** is of nonmagnetic material so as to magnetically insulate rotor **66** from stator frame **61** at the right end of the unit.

When field coil **63** is energized a magnetic circuit will be established as shown by the arrows, and the flux will travel across the air gap G between laminations **67** and the cylindrical portions **59** of the bell **62** into the enlarged portion of the rotor shaft **65** and into rotor **66** and out through the four equally spaced narrow rotor poles **70** to stator **68**, through to the stator frame **61** and back through end bell **62** and cylinder **59**. Portions of this flux path with continuous flow of flux need not be laminated but laminations are required in stator **68** and the rotor portion **67** at air gap G.

This generator construction eliminates the need for slip rings and brushes. If desired, the use of a non-magnetic bell **69** may be dispensed with and the right hand end of the generator constructed like the left hand end with the field coil divided into right and left portions.

Referring to Fig. 8 as the rotor **66** revolves a full sine wave of potential will be generated during the small portion of rotor movement represented by narrow poles **70** going by stator teeth **71**, windings **72** being provided on teeth **71** and connected in series to add their voltages at each actuation or in parallel or series-parallel as desired.

These coils **72** supply a transformer distributor system with rectifier **30** as shown in Figs. 1 and 4 providing ignition impulses to the spark plugs or other ignition devices.

The system of this invention thus produces the spark impulse in simple adaptable apparatus which dispenses with the breaker points and other features of the usual magneto and battery systems, and at the same time attains superior half-cycle sparks all of the same sign and precisely spaced. This gives a simple, definite sparking period for each firing period and avoids the spark plug erosion incident to surplus sparking. The single polarity of the impulses also adds to the

life of the spark plug by employing proper polarity for all firing.

It will be observed that, when the rectifier is employed, only unidirectional voltage and current impulses are fed into the ignition transformer. It is important with such a circuit that progressive saturation of the transformer does not occur and this may be taken care of by one of three methods which are:

a. If the transformer is of conventional construction with four lapped joints at the corners of the core and the laminations are painted to prevent eddy currents, as is normally the case, four small air gaps in series are thus provided which ordinarily will prevent such progressive saturation and will permit the flux in the transformer core to substantially reach zero between successive unidirectional impulses.

b. This method may be carried somewhat further if found desirable by actually providing one or more additional air gaps **32** in the magnetic circuit (Fig. 4).

c. Some electrical advantage is obtained and a smaller core may be employed by negatively biasing the transformer with a separate winding carrying direct current. In order to prevent the generator impulses from changing the current in this direct current circuit, which would tend to nullify its value, this biasing coil **31** may be designed for connection in series with the impulse generator field and the inductance of the impulse generator field will maintain this biasing current at a substantially constant value.

While the invention has been shown and described in connection with specific embodiments thereof, it is not intended to be confined thereto. Various substitutions and additions may be made without departing from the principle of the invention. For instance, permanent magnet fields may be provided instead of the electromagnets shown and the invention is intended to cover such variations as fall within the scope of the appended claims.

I claim:

1. In an internal combustion engine ignition system, the combination of an impulse generator driven by the engine in timed relation and having armature and field pole structures adapted to produce solely through relative rotation therebetween a potential output consisting of full wave, steep front voltage impulses of the same starting polarity in synchronism with the firing periods of the engine, with a period of substantially zero potential generation between successive impulses, a step-up transformer having its primary connected to the output terminals of said generator and a load circuit connected to the secondary of said transformer and including spark gap means for said engine periodically energized by said impulses.

2. In an internal combustion engine ignition system, the combination of an impulse generator driven by the engine in timed relation and having armature and field pole structures adapted to produce solely through relative rotation therebetween successive voltage impulses of the same starting polarity in synchronism with the firing periods of the engine, with a period of substantially zero potential generation between successive impulses, a step-up transformer having its primary connected to the output terminals of said generator, a rectifier connected in series with said primary of said transformer passing a selected polarity half cycle and blocking passage of the opposite polarity half cycle of each impulse, and a spark plug in series with the secondary of said transformer.

3. In an internal combustion engine ignition system, the combination comprising a step-up transformer having primary and secondary windings, a generator driven by the engine at a rate correlated to engine speed and having an armature winding connected in closed circuit relation with said primary winding, a plurality of angularly spaced, narrowed field poles of the same polarity cooperating successively with said armature winding and generating therein spaced, individual potential impulses of like starting polarity and of steep front wave form at periods corresponding to the firing periods of the engine, means for completing the magnetic circuit at a point remote from said field poles each time a field pole coacts with said armature winding in the generation of an impulse, a load circuit connected to said secondary winding and including a plurality of spark plugs and a distributor driven by the engine for connecting said secondary winding with said spark plugs successively in synchronism with the periods of impulse generation, and rectifying means connected in series in the circuit between said armature winding and said primary winding restricting the impulses passing through the latter to a single polarity, whereby unidirectional impulses are supplied to said spark plugs.

4. The system as defined in claim 3 further including a laminated core for said transformer of closed loop form, and means coacting with said core for preventing progressive saturation thereof.

5. In an internal combustion engine ignition system, the combination consisting of an impulse generator driven by the engine in timed relation and having a generating coil composed of windings embracing diametrically disposed, narrow stator teeth, and a rotor provided with diametrical, narrowed field poles of one polarity and intermediate poles of opposite polarity and of long circumferential length, whereby the output from said generating coil consists of full wave voltage impulses of steep front wave form and of like starting polarity in synchronism with the firing periods of the engine, with a period of substantially zero potential generation between successive impulses, a rectifier, a step-up transformer having its primary connected in series circuit relation with said generating coil and said rectifier, and a high tension circuit including the secondary of said transformer, a plurality of spark plugs and a distributor driven by the engine.

6. In an internal combustion engine ignition system, the combination consisting of an impulse generator driven by the engine in timed relation and having a generating coil composed of windings embracing diametrically disposed, narrow stator teeth, and a rotor provided with diametrically opposite pairs of angularly spaced, narrowed field poles of the same polarity and opposite polarity poles of long circumferential length between said pairs, whereby the output from said generating coil consists of full wave voltage impulses of steep front wave form and of like starting polarity in synchronism with the firing periods of the engine, with a period of substantially zero potential generation between successive impulses, a rectifier, a step-up transformer having its primary connected in series circuit relation with said generating coil and said rectifier, and a high tension circuit including the secondary of said transformer, a plurality of spark plugs and a distributor driven by the engine.

7. In an ignition system of the character de-

scribed, a generator having a stator provided with a plurality of angularly spaced generating windings embracing narrow stator teeth and a rotor formed with similarly spaced, narrowed field poles and means including an end bell in which said rotor is journalled completing a magnetic circuit through the stator and rotor, said poles being of the same polarity and coacting simultaneously with said windings upon rotation past said stator teeth to produce a potential output consisting of full wave, steep front voltage impulses recurrent at predetermined intervals and of the same starting polarity with a period of substantially no potential generation between successive impulses, a half wave rectifier, a step-up transformer having its primary connected in series with said rectifier and said generating windings, and a high tension ignition circuit connected to the secondary of said transformer and including ignition means periodically energized by said impulses.

8. A system for supplying electrical ignition impulses to the spark plugs of an internal combustion engine, comprising a distributor for distributing high tension impulses to the respective spark plugs in their order of firing, a step-up transformer having primary and secondary windings, said secondary winding connected to said distributor,

a generator winding, means consisting of conductors connecting said generator winding with said primary winding, magnetic field means cooperating with said generating winding and including a polar member driven by the engine and passing full density magnetic flux through said generating winding in one direction at intervals corresponding to the firing periods of the engine to generate individual, potential impulses of steep front full wave form spaced from each other with a period of substantially zero potential generation therebetween, and of like starting polarity, and a half wave rectifier connected in the circuit between said generating and primary windings passing a selected polarity half cycle of each impulse for energization of said transformer at precisely timed intervals.

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

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Number	Name	Date
1,225,534	Varley	May 8, 1917
2,382,808	Ochsenbein	Aug. 14, 1945

Certificate of Correction

Patent No. 2,450,404. September 28, 1948.

DONALD I. BOHN

It is hereby certified that errors appear in the printed specification of the above numbered patent requiring correction as follows:

Column 5, lines 74 and 75, and column 6, line 1, claim 2, strike out "half cycle and blocking passage of the opposite polarity half cycle of each impulse" and insert instead *of said impulses*;

and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of June, A. D., 1949.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.

Certificate of Correction

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[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.