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IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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Fig. 1.

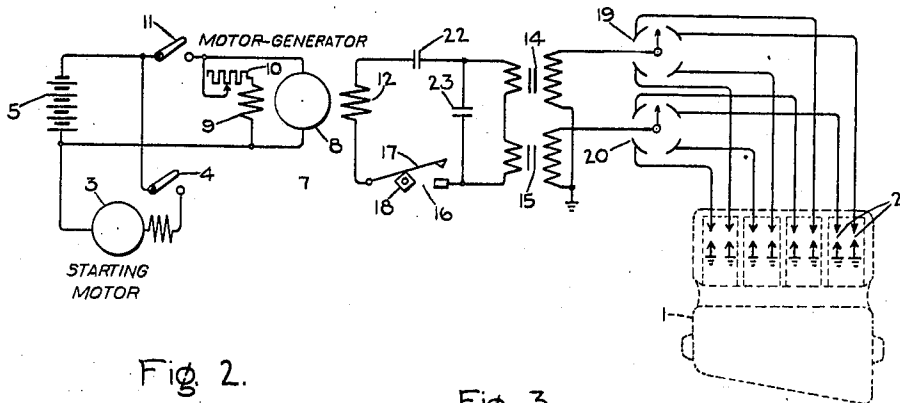


Fig. 2.

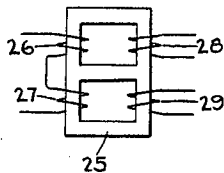
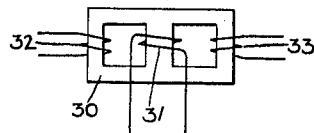


Fig. 3.



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UNITED STATES PATENT OFFICE

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IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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5 Claims. (Cl. 123—148)

My invention relates to ignition systems for internal combustion engines and particularly to ignition systems wherein sparks in rapid succession are produced in the engine cylinder by a high frequency alternating current. Such a system is disclosed and claimed in the application of Max A. Whiting, Serial No. 757,545 filed concurrently herewith. In the system disclosed by the above mentioned application, the high frequency ignition current is produced by a motor-generator apparatus which is driven from a battery which also is arranged to energize the starting motor of the engine. It is one object of my invention to provide an improved ignition system of this character whereby the voltage of the high frequency alternating current supplied to the spark gaps of the engine is maintained substantially uniform notwithstanding the variations which may occur in voltage of the battery.

In an ignition system of this character it has been found desirable under certain conditions to provide a plurality of spark gaps in the engine cylinder or in each cylinder in the case of a multi-cylinder engine. It is another object of my invention to provide an improved ignition system of this character employing high frequency alternating current and providing a plurality of spark gaps in each cylinder which system will insure that a succession of sparks will occur at all the spark gaps in each cylinder.

A further object of my invention is the provision of an improved ignition system of this character in which the voltage applied to the spark gap or gaps of the engine is automatically made higher when the gap or gaps are not conducting.

My invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Referring to the drawing, Fig. 1 is a circuit diagram representing one embodiment of my invention and Figs. 2 and 3 show two modified forms of the transformers shown in Fig. 1. In Fig. 1, I have shown by dotted lines the internal combustion engine 1 which engine may be of the fuel injection or semi-Diesel type and may have a single cylinder or may have a plurality of cylinders. I have represented the engine as a four-cylinder engine provided with the spark gaps 2, each of which may comprise a spark plug of any suitable and well known form. Inasmuch as it has been found that under certain conditions improved operation is obtained by the use of a plurality of spark gaps in each cylinder, I

have shown the engine as provided with two gaps for each cylinder. The engine also is provided with starting apparatus by means of which it may be cranked electrically. This apparatus may be of any suitable and well known form including an electric motor which I have represented at 3 connected through the starting switch 4 with the usual storage battery 5. This battery, it will be understood, may be kept charged by being supplied from a suitable generator driven from the engine in the well known manner but as such charging means forms no part of my present invention it has been omitted from the drawing in order to simplify the showing.

Energy is taken from the battery 5, converted into high frequency alternating current and supplied to the engine for ignition purposes. The means which I have illustrated for so converting the energy is the motor-generator apparatus 7 which may be of any suitable and well known form adapted to be operated from the battery 5 continuously, that is, while the engine is running and to produce the desired high frequency alternating current. I have found that a convenient form of motor-generator apparatus is a dynamotor of the inductor type which on the drawing is represented as having a motor element including the rotor 8 and the shunt field winding 9 controlled by the rheostat 10 which element is connected through the switch 11 with the battery 5. The dynamotor is thereby connected to the battery in shunt with the starting motor. The generator element of the dynamotor is represented as comprising the winding 12 which at normal operating speed of the dynamotor is constructed to produce alternating current having a frequency of the order of 2500 to 3000 cycles per second.

Connected in a series circuit with the winding 12 are the primary windings of the step-up transformers 14 and 15 and the motor operated switch 16. The latter may be of any desired form and for convenience is represented as comprising the switch arm 17 actuated by the cam 18 which is driven by the engine. This switch 16 while represented as being of a form similar to that of the well known igniter switch of an internal combustion engine of the common explosive type does not function in the manner of such an igniter switch since the opening of the circuit by the switch 16 is not for the purpose of producing a spark in the engine cylinder. The purpose of the switch in the present case is to maintain the alternating current circuit

closed through those intervals only during which it is desired to have a rapid succession of sparks occur in the engine, it being noted that the time during which fuel is being injected into a cylinder of an engine of the injection type is only a relatively small part of the complete cycle. The secondaries of the transformers 14 and 15 connect respectively through the distributors 19 and 20 with the spark gaps 2 whereby one transformer supplies current to one gap of each cylinder and the other transformer supplies current to the other gap of each cylinder.

The above described apparatus is constructed to produce the desired voltage and frequency of the alternating current applied to the spark gaps when the dynamotor is supplied with the normal battery voltage. If for any reason the battery voltage is somewhat below normal, due for example to a partially discharged condition of the battery or to a drop in voltage incident to the operation of the starting motor in cranking the engine, the speed of the dynamotor will be reduced and hence its alternating current voltage and frequency will also be reduced. For the purpose of lessening such a decrease in the voltage and frequency of the output of the dynamotor, I have provided the capacitor 22 in the above-mentioned series circuit which includes the winding 12, the transformer primaries and the switch 16, it being understood that the generator winding 12 of the dynamotor is inductive. The capacitance of the capacitor 22 is so related to the inductance of the winding 12 that the point of resonance corresponds to a frequency and hence to a speed of the dynamotor, which is below that speed at which the dynamotor ever would be driven under proper operating conditions. As a result of this construction it will be seen that although a small decrease in speed of the dynamotor may occur due to a drop in battery voltage, the voltage applied to the transformers 14 and 15 will remain approximately the same since the impedance in the circuit of the transformer primaries decreases when the frequency decreases.

When dual ignition is provided for as in the present case by the two spark gaps in each cylinder it is desirable, in order to minimize the amount of equipment, that both gaps should be supplied from the same source of alternating current voltage and that there should be a breakdown in both gaps in each cylinder.

Unlike the common single spark battery ignition systems in common use where the energy of the single spark is that stored in the induction coil employed, the energy for the rapid succession of sparks in my apparatus is supplied by the alternating current source, the supply being continuous during each period of sparking. For this purpose the source of alternating current is not limited to that described above but may comprise any suitable and well known means for producing an alternating current of the desired voltage and frequency.

Inasmuch as the resistance across a spark gap greatly decreases as soon as the gap becomes ionized due to breakdown, it is necessary that there be a fairly large impedance in the supply circuit so as to limit the flow of current to the spark gap. With such a circuit, if the spark gaps are supplied from a single source in a parallel arrangement, one gap may begin to conduct before the other and the current flow thereto will cause the voltage applied to the other gap to drop due to the circuit impedance. Hence because of the drop in voltage resulting from the breakdown of

one spark gap the second spark gap will not break down.

In accordance with another feature of my invention I have provided means for insuring the firing of both gaps in each cylinder. In effect, the two gaps of a cylinder are arranged in series. However, this is not done by an actual series arrangement of the gaps but it is brought about by arranging the primaries of the transformers 14 and 15 in series which arrangement produces substantially the same result and avoids the otherwise necessary expedient of either a special spark plug construction or a special distributor construction involving insulation difficulties. Since the two transformers have the same construction there will be an equal division of the voltage applied across the primary windings before spark gap breakdown occurs. With this arrangement should one only of the two gaps in a cylinder break down and a rapid succession of sparks begin in the one gap and not in the other, the resulting decrease in impedance of the secondary circuit supplying said one gap, the gap being then ionized, immediately would cause a material decrease in the voltage drop across the corresponding primary. Consequently nearly the entire voltage of the source would then appear across the other primary, raising the voltage of the other secondary until the other gap breaks down and the succession of sparks begins there also.

It should be noted that not only does substantially the entire voltage of the generating source appear at the transformer whose secondary is not conducting, but this voltage is maintained at its no load value because there can be no large flow of primary current when only one secondary is conducting. This is due to the fact that the no load impedance of the primary of the transformer whose secondary is not conducting is imposed in the circuit. As soon as both spark gaps conduct, the current is limited primarily by the impedance of the supply circuit.

While as stated above the source of alternating current voltage may comprise any suitable and well known means, various means such as those including electron discharge tube oscillators having been successfully used for this purpose, I have found it convenient to employ a generator having an inductive winding such, for example, as the dynamotor described above. With such a generator the inductance of the winding supplies substantially all the necessary circuit impedance for limiting the flow of current to the spark gap.

By another feature of my invention I am able to cause an automatic rise in the voltage applied to the transformers 14 and 15 when the secondaries thereof are not conducting. This I accomplish by connecting the capacitor 23 across the primaries of transformers 14 and 15, which capacitor has an impedance which is no greater but preferably somewhat less than the magnetizing or no load impedance of the transformers 14 and 15. When the transformer secondaries, therefore, are not conducting the current drawn from the generator has a leading power factor. It is well known that the effect of a leading power factor where the current is supplied by a generator having a large inductive reactance is to raise the terminal voltage. Hence the effect of capacitor 23 in the circuit is to raise the voltage applied to the transformers 14 and 15 before breakdown of the gaps occurs. While I have described the above circuit arrangement including two transformers 14 and 15, it will be under-

stood that the same phenomenon would take place if a single transformer were employed instead of two transformers as illustrated and a single gap employed in each cylinder.

5 In Fig. 2 I have illustrated a single transformer construction which may be substituted for the two separate transformers illustrated in Fig. 1. As shown in Fig. 2 the transformer has a single core structure 25 in the form of a figure 8 pro-
10 vided with the two primary windings 26 and 27 wound in the same direction and provided with the two secondary windings 28 and 29.

In Fig. 3 I have shown a further modified form of transformer which has a single core structure
15 30 somewhat like that shown in Fig. 2 but which has a single primary winding 31 on the central leg of the core and the two secondary windings 32 and 33 on the other two legs.

I have shown the particular embodiment described as illustrative of my invention and it will be apparent that various modifications may be made without departing from the spirit and scope of my invention which modifications I aim to cover by the appended claims.

25 What I claim as new and desire to secure by Letters Patent of the United States, is:

1. A multi-spark ignition system for an internal combustion engine having a spark gap comprising an inductive source of alternating current, a transformer having its primary connected
30 in circuit with said source and its secondary connected with said spark gap and a capacitor connected across said primary, the impedance of said capacitor being substantially no greater than the
35 no load impedance of said transformer.

2. A multi-spark ignition system for an internal combustion engine having a spark gap comprising an alternating current generator having an inductive generating winding, a switch, a
40 transformer having its primary connected in a series circuit with said winding and switch and its secondary connected with said spark gap and a capacitor connected across said primary, the impedance of said capacitor being less than the
no load impedance of said transformer.

3. A multi-spark ignition system for a multi-cylinder internal combustion engine having a plurality of cylinders each provided with a plurality of spark plugs comprising a high frequency alternating current generator having an inductive
5 generating winding, an engine operated switch, a plurality of transformers, means connecting the primaries thereof in a series circuit with said winding and switch, means for connecting the
10 secondaries of said transformers each with one spark plug in each cylinder and a capacitor bridged across said primaries, said capacitor having an impedance less than the no load impedance of said transformers.

4. A multi-spark ignition system for an internal combustion engine having a spark gap comprising an alternating current generator having an inductive winding, a switch, a capacitor, a
15 transformer having its primary connected in a series circuit with said generator winding, said switch, and said capacitor, means connecting the secondary of said transformer with said spark
20 gap and a capacitor bridged across said primary.

5. A multi-spark ignition system for a multi-cylinder internal combustion engine having a plurality of cylinders each provided with a plurality
25 of spark plugs comprising a high frequency alternating current generator having an inductive generating winding, an engine operated switch, a capacitor, a plurality of transformers, means
30 connecting the primaries thereof in a series circuit with said winding, said switch and said capacitor, the capacitance of said capacitor being such that the series circuit is resonant at a frequency
35 corresponding to a speed less than the normal operating speed of the generator, means connecting the secondaries of said transformers each with one spark plug in each cylinder and a capacitor bridged across said primaries, said
40 last mentioned capacitor having an impedance less than the no load impedance of said transformers.

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