

[54] **CAPACITOR DISCHARGE IGNITION
SYSTEM WITH AUTOMATIC SPARK
ADVANCE**

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[51] Int. Cl. **F02p 3/06**

[58] Field of Search 123/148 E, 149 D; 315/209 CD, 315/209, 218

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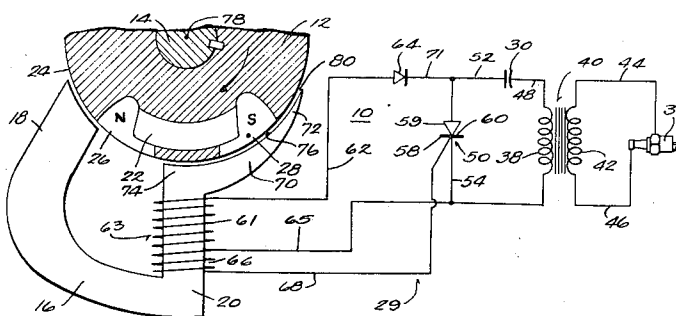
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[57] **ABSTRACT**

Disclosed herein is a capacitor discharge ignition system which utilizes a magneto-type flywheel assembly with a permanent magnet located in the flywheel to induce a voltage pulse in a charge coil located on one leg of a U-shaped coil core to charge a capacitor and to induce a trigger pulse in a trigger coil to trigger a silicon controlled rectifier which thus becomes conducting and closes a circuit between the capacitor and the primary coil of a transformer for discharge of the capacitor. In the disclosed construction, the charging and triggering coils constitute portions of a single coil to advance the time at which the capacitor discharges and accordingly to fire the associated spark plug prior in time to the normal firing time in relation to engine crankshaft position, the coil core is provided with an extension or foot which extends circumferentially of the flywheel in the direction opposite flywheel rotation.

17 Claims, 7 Drawing Figures



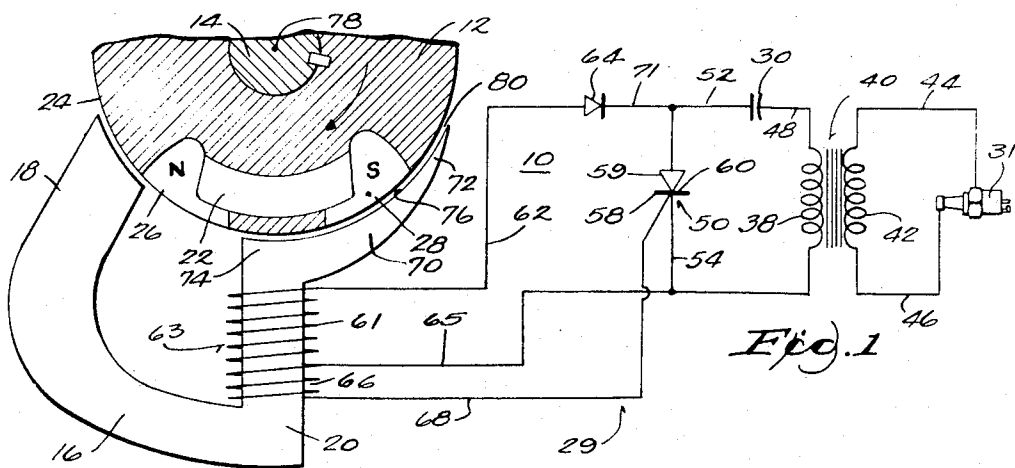


Fig. 1

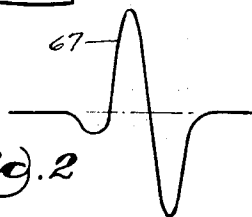


Fig. 2

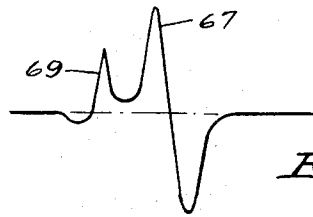


Fig. 3

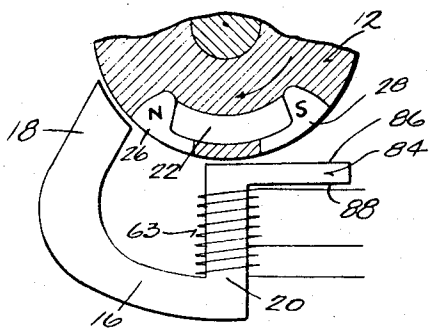


Fig. 4

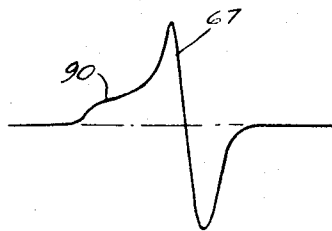


Fig. 5

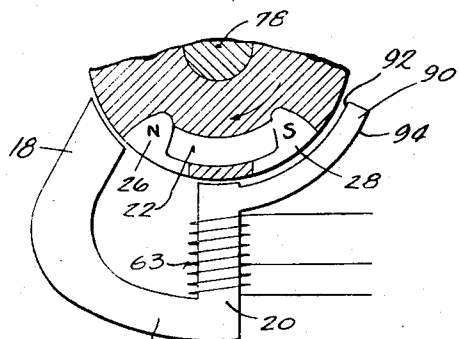


Fig. 6

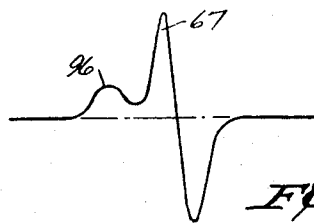


Fig. 7

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CAPACITOR DISCHARGE IGNITION SYSTEM WITH AUTOMATIC SPARK ADVANCE

RELATED CASE

This application is a continuation of my earlier application, Ser. No. 647,426, filed June 20, 1967 now abandoned.

SUMMARY OF INVENTION

The invention provides an engine ignition system comprising magnetic means including a rotary member and a fixed member with one of the members having means to induce flux travel in the other of the members and with the other member including a core extending to adjacent the one member. The ignition system also includes an ignition circuit including a spark means, a capacitor connected to a spark means, a thyristor connected to the capacitor and including a gate, together with a coil wound upon the core and including a first end tap, a second end tap connected to the gate, and a center tap dividing the coil into a charge portion between the first end tap and the center tap and a trigger portion between the center tap and the second end tap. The trigger portion and the charge portion are concentrically wound in the same direction relative to the flux travel and are simultaneously subject to the same lines of flux.

The invention also provides a capacitor discharge ignition system with provision to advance the spark, i.e., to advance the firing time of the spark plugs in relation to engine crankshaft position, as the engine speed passes above a predetermined engine speed.

In one particular embodiment, the invention is embodied in a magneto-type flywheel assembly with a permanent magnet located in the periphery of the flywheel. This embodiment also includes a U-shaped core having two legs adjacent the flywheel with a coil having a first portion constituting a charge coil and having a second portion constituting a trigger coil located on the same leg. Rotation of the flywheel and magnet induces a first voltage pulse in the trigger coil which triggers or makes conducting a silicon controlled rectifier in the ignition circuit. Such rotation also induces a voltage pulse in the charge coil to charge the capacitor for subsequent discharge, consequent to operation of the trigger coil. Thus when the silicon controlled rectifier is in a conducting state, a circuit connecting a capacitor to the primary coil of a step up transformer is closed and the capacitor discharges creating an ignition voltage in a transformer secondary coil which in turn fires a spark plug.

The invention includes provision of a foot or extension on the core leg having the trigger coil and charge coil. The foot extends circumferentially of the flywheel in the direction opposite flywheel rotation. As the flywheel rotates, the permanent magnet reaches the toe of the foot prior to reaching the heel of the foot which is located at the end of the core leg. The magnet induces a voltage spike or pulse in the trigger coil which is in advance of and which leads the normal spike or pulse induced in the trigger coil as the permanent magnet approaches the heel of the foot. However, the leading pulse is less in magnitude than the normal pulse produced at the heel.

The voltage pulse induced when the permanent magnet approaches the heel of the foot is sufficient to trigger the silicon controlled rectifier and fire the capacitor when the engine is operating within a predetermined low engine speed range. The voltage necessary to make the silicon controlled rectifier conducting remains constant. However, the leading voltage pulse induced by the toe of the foot is not sufficient to fire the silicon controlled rectifier within the low engine speed range. Since the magnitude of the generated or induced voltages varies with the speed of the permanent magnet, as the engine speed increases beyond the predetermined speed, the leading pulse increases in magnitude until it is sufficient to make the silicon controlled rectifier conducting and thus discharge the capacitor to fire the spark plug in advance of the normal pulse.

The foot shape, foot length, and the space or air gap between the foot and the periphery of the flywheel determine

the reluctance of the flux path and accordingly the shape and magnitude of the leading voltage spike at any particular engine rate of revolution. Accordingly, the speed at which the silicon controlled rectifier will be triggered in advance can be selected by choice of foot configuration.

Further objects and advantages of the invention will become apparent from the following description and accompanying drawings.

DRAWINGS

FIG. 1 is a diagrammatic view of a capacitor discharge ignition system in accordance with the invention.

FIG. 2 is a wave form of the voltage induced in the trigger coil by an ignition system embodying a portion of the invention.

FIG. 3 is a voltage wave form produced by the embodiment of the invention shown in FIG. 1.

FIG. 4 is a fragmentary view of a modified embodiment of the invention.

FIG. 5 is a voltage wave form produced by the embodiment shown in FIG. 4.

FIG. 6 is a further embodiment of the invention.

FIG. 7 is a voltage wave form produced by the embodiment shown in FIG. 6.

DETAILED DESCRIPTION

In the drawings, there is shown a capacitor discharge ignition system which is generally designated 10 and which includes a rotating member or flywheel 12 keyed to an engine crankshaft 14. The ignition system 10 includes a fixed member which further includes a generally U-shaped coil core 16 which has a web and side legs 18 and 20. The flywheel also includes a permanent magnet 22 located adjacent the flywheel periphery 24 with a north pole or shoe 26 and a south pole or shoe 28.

Although the disclosed ignition system shows the permanent magnet located in the rotating member, the flywheel 12, an alternate arrangement could locate the permanent magnet in the fixed member with the coil core 16 located in the rotating member.

The ignition system comprises a circuit 29 which can be in many forms and which in the illustrated embodiment includes a capacitor 30 which serves as an energy storage device providing the energy to fire the spark discharge means 31 which is in the form of a spark plug. A voltage is supplied to spark plug 31 by discharge of the capacitor 30 through the primary winding or coil 38 of a step up transformer 40 which has a secondary winding or coil 42 with leads 44 and 46 respectively connected to the spark plug 31. One side of the capacitor 30 is connected to the primary coil 38 by a lead 48. The circuit 29 also includes switch means 50 which is normally open and which prevents capacitor discharge when the switch is not closed. In the disclosed circuit the switch means is in the form of a thyristor or silicon controlled rectifier having a gate 58, an anode 59 and a cathode 60. The switch could be a vacuum tube. The capacitor 30 is connected to the anode 59 by a lead 52. The cathode 60 is connected to the primary winding 38 by a lead 54.

Although the capacitor 30 can be charged in various ways, as for instance by a battery, in accordance with the invention, in the disclosed circuit the capacitor 30 is charged by a charge coil 61 which comprises a portion of a coil 63 which is located adjacent the flywheel 12 on core side leg 20 and which has a tap intermediate the ends of the coil 63. The coil 63 also includes a trigger coil portion 66. One side or end tap of the charge coil 61 is connected by a lead 62 to a diode 64 and a lead 71 connects the diode 64 to the capacitor 30. The diode 64 prevents capacitor discharge through the charge coil 61.

The other side or end tap of the charge coil 61, i.e., the intermediate tap is connected to the primary winding 38 of the transformer 40 by a lead 65. The other side of the primary winding 30 is connected to the capacitor by lead 48.

Further in accordance with the invention means are provided operable below a predetermined engine speed to close the switch means or trigger the silicon controlled rectifier 50 to afford discharge of capacitor 30 across the primary coil 38 of the transformer 40. In the disclosed circuit, the means comprises the trigger coil or winding 66 which has an end tap connected to the gate 58 of the silicon controlled rectifier by a lead 68 and which is also connected through the intermediate tap by the leads 65 and 54 to the cathode 60 of the switch means and to the primary winding 38.

In operation of the device as thus far described, as the magnet pole 26 leaves the core leg 18 and as pole 28 leaves the core leg 20 a positive voltage is generated in the charge coil 61 and a negative voltage in the trigger coil 66. The voltage polarities referred to herein are measured with respect to the cathode of the silicon controlled rectifier 50. The negative voltage in the trigger coil 66 causes a negative gate current in the silicon controlled rectifier 50. The negative gate current will not close or make conducting the silicon controlled rectifier between the capacitor and the primary winding 38. However, the positive voltage in the charge coil 61 causes a current flow through the diode 64 and thus the capacitor 30 is charged to the peak value of the voltage in the charge coil 61. The capacitor 30 remains charged until the magnet pole 26 approaches the core leg 18 and the pole 28 approaches the core leg 20. As the pole 28 approaches the core leg 20, a positive voltage or pulse 67 (FIG. 2) is induced in the trigger coil 66 and a negative voltage in the charge coil 61.

The negative voltage in the charge coil 61 is blocked by the diode 64. The positive voltage in the trigger coil 66 causes a positive silicon controlled rectifier gate current and thus makes the silicon controlled rectifier conducting. When the silicon controlled rectifier is conducting, the capacitor 30 discharges through the silicon controlled rectifier 50 causing a voltage in the primary winding 38 of the transformer 40. This induces a voltage in the secondary coil 42 which fires the spark plug 31.

Thus, firing of the spark plug occurs when the rotating member or flywheel 12 is in a predetermined first relative position to the fixed member or coil core 16 and after reversal of the voltages in the charge and trigger coils. Accordingly, the time at which ignition occurs is fixed relative to engine crankshaft position.

In accordance with the invention, means are provided extending from the core 16 for affecting the pulse induced in the trigger portion 66 so as to advance the time when the thyristor 50 is made conducting upon increase in the rate of relative rotation between the fixed member 16 and the rotary member 12. Such means advances the time at which ignition occurs by providing a voltage pulse 69 as shown in FIG. 3 which leads or is in advance of the pulse 67 generated by the trigger coil as the permanent magnet 28 passes the core leg 20. This leading pulse 69 makes the silicon controlled rectifier 50 conducting prior to the point in time during which the magnet 28 and the core leg are at the predetermined relative position, and thus, the capacitor 30 is discharged prior in time causing spark discharge in the spark plug 31. In this disclosed construction the means provided extending from the core 16 for affecting the pulse induced in the trigger portion 66 so as to advance the time when the thyristor 50 is made conducting upon increase in the rate of relative rotation between the fixed member 16 and the rotary member 12 comprises a foot 70 having a toe 72 and a heel 74 located at the end of the core leg 20. The foot 70 extends generally circumferentially of the flywheel 12 in a direction opposed to the direction of rotation of the flywheel 12 which in the disclosed construction is clockwise. In the foot illustrated in FIG. 1, the foot has an inner surface 76 concentric with the axis of rotation 78 of the shaft 14 and the flywheel 12. The surface 76 is separated from the flywheel 12 by an air gap 80. In operation, the foot 70 of FIG. 1 induces a voltage spike or pulse 69 in advance of the voltage pulse 67 which is induced in the trigger coil 66 when the pole 28 approaches the heel 74. The pulse 69 is produced when the gap between the

poles 26, 28 is centered over the tip of the foot 70. The voltage pulse 69 is smaller in magnitude than voltage pulse 67 and leads the pulse 67 in time. With increase in engine speed beyond a predetermined speed, the magnitude of the voltage pulse 69 is increased until it is sufficient to make the silicon controlled rectifier 50 conducting and cause the capacitor 30 to discharge in the primary 38 and induce an ignition voltage in the secondary 42 of the transformer 40. The capacitor 30 is recharged in the same manner as previously described, i.e., the capacitor is charged by a positive pulse induced in the charge coil 61 when the pole 26 leaves leg 18 and the pole 28 leaves the leg 20 in the direction of rotation of the rotating member 12.

Inasmuch as the shape and magnitude of the leading voltage spike or pulse 69 is dependent upon the shape and length of the foot and the spacing from the flywheel 12, the rate of rotation at which it is desired to advance the spark plug firing time can be predetermined and controlled by the use of various foot configurations. As shown in FIG. 4, in accordance with the invention, there is provided a foot 84 having two parallel opposed surfaces 86 and 88 which diverge from the rotating member 12. As shown in FIG. 5, such construction produces a leading pulse 90 which has a gradual slope. With the use of a foot having this configuration, the engine speed at which the silicon controlled rectifier is fired would be substantially greater than the foot configuration shown in FIG. 1. In FIG. 6 there is shown a third foot 90 having two surfaces 92 and 94 which are concentric with the axis of rotation 78 of the engine crankshaft 14 and flywheel 12. The construction shown in FIG. 6 produces a pulse 96 as shown in FIG. 7, which is greater in magnitude than the pulse 90, shown in FIG. 5. The surface 92 is spaced at a greater distance from the flywheel periphery 24 than the heel 74 to provide a greater air gap and thus increase the speed at which spark advance occurs.

Although the disclosed embodiments show the foot located on the core leg having the trigger coil and charge coil, it is within the purview of the invention to locate the foot on the rotary member. In the alternative, the foot can be located on a stationary of fixed permanent magnet and the trigger and charge coils located within the flywheel.

Various of the features of the invention are set forth in the following claims.

I claim:

1.

An engine ignition system comprising magnetic means including a rotary member and a fixed member with one of said members having means to induce a voltage in the other of said members, said member in which said voltage is induced including a coil core located adjacent the periphery of the other of said members to provide a path for flux travel occurring incident to relative rotation between said fixed and rotary members, an energy storage means, switch means for controlling discharge from said energy storage means to an ignition coil, said switch means including a control terminal, and a coil wound on said core and linked by lines of flux traveling in said path, said coil having a pair of spaced end taps and an intermediate tap dividing the said coil into a trigger portion defined between one of said end taps and said intermediate tap and a charge portion defined between said intermediate tap and the other of said end taps, said trigger portion and said charge portion being wound in the same direction relative to the travel of the flux, and being concentric to each other, and both being simultaneously linked by the same lines of flux traveling in said path, said charge portion being electrically connected to said energy storage means and said one end tap of said trigger portion being electrically connected to said control terminal of said switch means.

2. An engine ignition system in accordance with claim 1 wherein said rotary member contains a permanent magnet located adjacent the periphery thereof and wherein said fixed member includes said coil and said coil core.

3. An engine ignition system in accordance with claim 2 wherein said core includes a U-shaped member having a pair

of legs with one of the said legs being located so that any point on said rotary member travels past said one leg before traveling past the other of said legs, said core also including a foot projecting from the end of said one leg adjacent to said rotary member and extending circumferentially of said rotary member in the direction counter to the direction of rotation of said rotary member.

4. An engine ignition system in accordance with claim 2 wherein said core includes a U-shaped member having a pair of legs with one of said legs being located so that any point on said rotary member travels past said one leg before traveling past the other of said legs, said core also including a foot extending from the end of said one leg adjacent to said rotary member and counter to the direction of rotation of said rotary member and having an inner surface concentric to the axis of rotation of said rotary member and having a radial cross section which diminishes in the direction counter to the direction of rotation of said rotary member.

5. An engine ignition system in accordance with claim 2 wherein said core includes a foot having two opposed surfaces concentric to the axis of rotation of said rotary member.

6. An engine ignition system in accordance with claim 2 wherein said core includes a foot having a surface which diverges from said rotating member.

7. An engine ignition system in accordance with claim 2 wherein said core includes a foot having a heel and an inner surface spaced at a greater distance from said rotary member than said heel of said foot.

8. An engine ignition system magnetic means including a rotary member and a fixed member with one of said members having means to induce flux travel in the other of said members to create a voltage in the other of said members, said other member including a core extending to adjacent said one member, and an ignition circuit including a spark means, a capacitor connected to said spark means, a thyristor connected to said capacitor and including a gate, and a coil wound upon said core, said coil including a first end tap, a second end tap connected to said gate, and a center tap dividing said coil into a charge portion between said first end tap and said center tap and a trigger portion located between said center tap and said second end tap, being wound in the same direction relative to said flux travel as said charge portion, and being concentric with said charge portion and simultaneously subject to the same lines of flux as said charge portion.

9. An engine ignition system comprising magnetic means including a rotary member and a fixed member with one of said members having means to induce flux travel in the other of said members to create a voltage in the other of said members, said other member including a core extending to adjacent said one member, and an ignition circuit including a spark means, a capacitor connected to said spark means, a thyristor connected to said capacitor and including a gate, a coil wound upon said core, said coil including a first end tap, a second end tap connected to said gate, and an intermediate tap dividing said coil into a charge portion located between said first end tap and said intermediate tap and connected to said capacitor, and a trigger portion located between said intermediate tap and said second end tap, being wound in the same direction relative to travel of the flux as said charge portion, and being

concentric with said charge portion and simultaneously subject to the same lines of flux as said charge portion and connected to said gate whereby, incident to rotation of said rotary and fixed members relative to each other, said capacitor is charged in response to the induction of a voltage in said charge portion and said thyristor is made conducting in response to induction of a voltage in said trigger portion so as to effect discharge of said capacitor so as to cause creation of a spark by said spark means, and means extending from said core for affecting the pulse induced in said trigger portion so as to advance the time when said thyristor is made conducting upon increase in the rate of relative rotation between said fixed and rotary members.

10. An engine ignition system according to claim 8 wherein said fixed member comprises said core and said core has a leg with a foot extending in the direction counter to the direction of rotation of said rotary member and having an inner surface concentric with said rotary member and having a radial cross section which decreases in the direction counter to the direction of rotation of said rotary member.

11. An engine ignition system according to claim 8 wherein said fixed member comprises said core and said core is U-shaped having first and second legs and a connecting web portion and said second leg is spaced from said first leg in the direction counter to the direction of rotation of said rotary member, said core further including a foot extending from said second leg in said direction counter to the direction of rotation of said rotary member and having an inner surface concentric with said rotary member and having a radial cross section which decreases in the direction counter to the direction of rotation of said rotary member.

12. An engine ignition system according to claim 9 wherein said fixed member comprises said core and said core has a leg extending to adjacent the path of said rotary member and wherein said means extending from said core for affecting the pulse induced in said trigger portion includes a foot extending from the end of said leg adjacent to said rotary member and in the direction counter to the direction of relative rotation between said rotary and said fixed member.

13. An engine system in accordance with claim 12, wherein said foot extends circumferentially of said rotary member and has a radial cross section which decreases in the direction counter to the direction of rotation of said rotary member.

14. An engine ignition system in accordance with claim 12, wherein said foot has an inner surface concentric to the axis of rotation of said rotating member and has a radial cross section which decreases in the direction counter to the direction of rotation of said rotary member.

15. An engine ignition system in accordance with claim 12, wherein said foot has two opposed surfaces concentric to the axis of rotation of said flywheel.

16. An engine ignition system in accordance with claim 12, wherein said foot has a surface which diverges from said rotating member.

17. An engine ignition system in accordance with claim 12, wherein said foot has a heel and an inner surface spaced at a greater distance from said rotary member than said heel of said foot.

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