March 23, 1965 R. PENN ETAL 3,175,122

IGNITION SYSTEMS FOR INTERNAL COMBUSTION ENGINES

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Fig. 1.

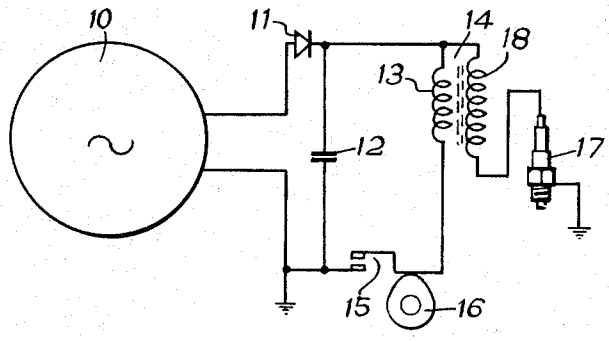
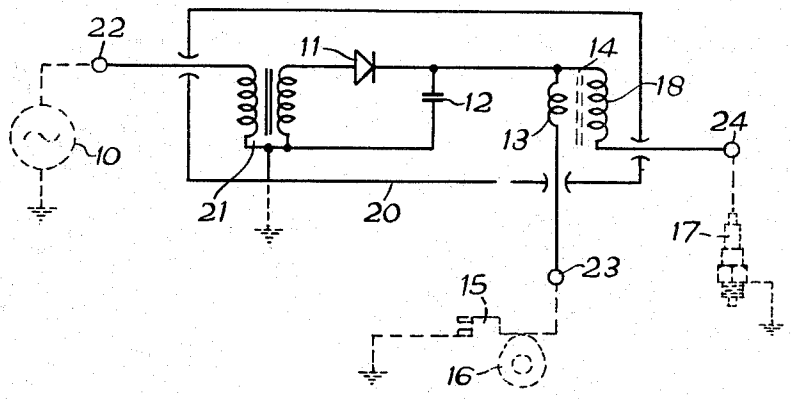


Fig. 2.



INVENTORS
REGINALD PENN
GEORGE ALFRED GAYLER
BY
Craig & Freudenberg
ATTORNEYS

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Fig. 3.

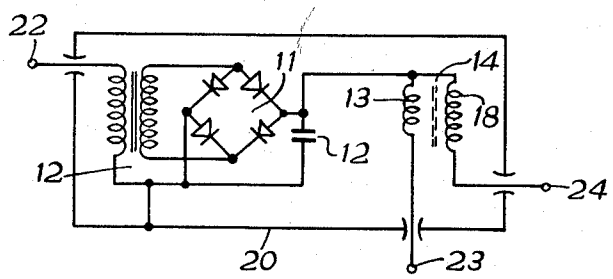
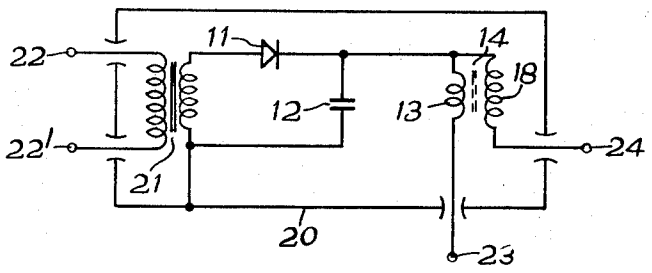


Fig. 4.



INVENTOR
REGINALD PENN
GEORGE ALFRED GAYLER
BY
Craig & Freudenberg
ATTORNEYS

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IGNITION SYSTEMS FOR INTERNAL COMBUSTION ENGINES

Reginald Penn and George Alfred Gayler, Bletchley, England, assignors to Wipac Development Limited, London, England, a British company

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15 Claims. (Cl. 315—209)

The present invention relates to ignition systems for internal combustion engines and is concerned with ignition systems of the type comprising a source of alternating current connected through a rectifier to a capacitor, and a radio-frequency voltage step-up transformer with its primary winding connected across the capacitor through make-and-break contacts, the secondary winding of the transformer being connected to a spark plug of an internal combustion engine.

Numerous different systems of this type have been proposed over a substantial number of years but this system has never been used widely for various reasons.

The most widely used ignition system is that usually referred to as the coil ignition system. This has an induction coil with a primary winding of few turns connected across a D.C. source through make-and-break contacts and secondary winding of some thousands of turns connected to the spark plug. Where there are two or more spark plugs a distributor is incorporated.

For any other ignition system to compete with the coil ignition system it must be of comparable cost or cheaper, it must be just as reliable or more reliable, and it must be just as effective or more effective.

The coil ignition system is cheap, robust and reliable but its effectiveness under certain adverse conditions leaves much to be desired. For example a fouled spark plug will often lead to the failure of a coil ignition system. Dampness likewise is troublesome with coil ignition systems and engine-starting under conditions of severe cold is often extremely difficult or impossible with coil ignition.

After consderable experimental work and trial we have devised an ignition system of the type specified which can be manufactured at a cost comparable with that of a coil ignition system, can be just as reliable as the coil ignition system and can be more effective than the coil ignition system under the adverse conditions hereinbefore referred to.

According to the present invention, in an ignition system of the type specified the capacitor has a capacitance within the range 0.1 to 0.5 μf., the voltage step-up transformer has a core of low loss ferro-magnetic material, a turns ratio of at least 50:1, a primary winding of 10 to 40 turns and an inductance measured across the primary winding of 4 to 30 μh., and the source of alternating current is such that the maximum inverse voltage across the rectifier is 800 volts. The transformer is preferably constructed as described in our copending patent application No. 862,380, entitled "Improvements in and Relating to Transformers."

The invention will now be described, by way of example, with reference to the accompanying drawings, in which—

FIG. 1 is a schematic diagram of an ignition system for a single-cylinder internal combustion engine, and

FIGS. 2, 3 and 4 are schematic diagrams of units for use in an ignition system.

Referring to FIG. 1, an ignition system for a single-cylinder internal combustion engine comprises an alternator **10** providing a maximum of 300 peak volts at normal engine speeds. A rectifier **11** and a capacitor **12** are connected in series across the alternator whereby the

maximum voltage across the capacitor **12** in normal operation is 300 volts.

The capacitor **12** has a capacitance between 0.1 and 0.5 μf. and preferably between 0.15 and 0.3 μf.

The primary winding **13** of a voltage step-up, spark plug transformer **14** is connected in series with make-and-break contacts **15** across the capacitor **12**. The contacts **15** are operated by a cam **16** and a spark plug **17** is connected across the secondary winding **18** of the transformer **14**.

With the capacitor **12** charged to 300 volts the maximum inverse voltage across the rectifier **11** is 600 volts.

The transformer **14** has a low-loss ferro-magnetic core that is a core such as a ferrite, iron dust in a binder and so on. Preferably a ferrite is used.

The turns ratio is preferably 70:1 and a turns ratio not less than 50:1 has been found to be necessary. The inductance measured across the primary winding has also been found to be important and must lie in the range 4 to 30 μh. The primary turns number between 10 and 40.

Provided the transformer meets these requirements its construction is otherwise not critical but is preferably as described in the aforesaid copending patent application.

In operation the capacitor is charged through the rectifier and is discharged periodically to fire the spark plug by closure of the contacts **15**. This causes the capacitor **12** to discharge through the primary winding of the transformer **14** inducing substantially increased voltage across the secondary winding **18** connected to the spark plug **17**.

It has been found that an ignition system as described is remarkably effective for operation under adverse conditions such as a fouled spark plug, dampness on the spark plug and in the cylinder and extreme. It has proved effective in starting and running an engine under examples of these conditions when conventional coil ignition systems have proved entirely ineffective. Nevertheless the cost of the system is about equal to that of a conventional coil ignition system.

Furthermore although it has been contended by experts for some years that at least 20 milli-joules of energy are required for effective ignition it has been found that effective ignition during starting with an ignition system according to the present invention can be obtained with less than 10 milli-joules of energy.

In applying the invention to an internal combustion engine already provided with an alternator adapted to generate a low voltage say 6 or 12 volts it is preferred to provide a unit consisting of a container housing a low-frequency transformer, the rectifier, the capacitor and the voltage step-up transformer for feeding the spark plug. The make-and-break contacts are driven by the engine and disposed outside the container.

A circuit diagram of a suitable unit is shown in FIG. 2. In FIG. 2 a metal container **20** houses a low-frequency, voltage step-up transformer **21**. An input terminal **22** is connected to one end of the primary winding of the transformer **21** the other end of the primary winding being connected to the container **20**. One end of the secondary winding of the transformer **21** is also connected to the container **20** and the other end is connected through the rectifier **11** to charge the capacitor **12**. The lower plate (in the drawing) of the capacitor **12** is connected to the container and the upper plate is connected to one end of the primary winding **13** of the transformer **14** the other end of the primary winding **13** being connected to a terminal **23**. The high-tension output from the secondary winding **18** of the transformer **14** is connected to an output terminal **24**.

In use the unit of FIG. 2 is connected as shown with the input terminal **22** connected to the source **10** of low

voltage, the output terminal 24 connected to the plug 17 and the terminal 23 connected through the make-and-break contacts 15 to ground. The container 20 is also grounded.

The transformer 21 transforms the voltage from the A.C. source to about 300 volts across the secondary winding at normal running speeds.

If desired the container can be made of insulating material such as a thermo-setting plastic in which case a fourth terminal is connected to the lower ends of the primary and secondary windings of the transformer 21 and the lower plate of the capacitor 12. The fourth terminal is grounded.

Although FIG. 2 shows a half-wave rectifier, a full-wave rectifier, such as a bridge rectifier, may be employed. FIG. 3 shows FIG. 2 modified to employ a bridge rectifier.

It will be seen that the only differences between the units shown in FIGS. 2 and 3 are that the secondary winding of the transformer 21 is not directly grounded and is connected across one diagonal of the bridge rectifier 11. The capacitor 12 is connected across the other diagonal of the bridge rectifier 11 and has its lower plate grounded.

Sometimes it may not be convenient to ground one terminal of the A.C. source 10 in which the unit may be as shown in FIG. 4 in which both ends of the primary winding are brought out to terminals as shown at 22 and 22' in FIG. 4. The unit shown in FIG. 4 is otherwise identical with FIG. 2.

Although the transformer 14 is shown as an auto-transformer, it can have separate primary and secondary windings.

We claim:

1. An ignition system for an internal combustion engine, comprising a source of alternating current, a capacitor having a capacitance within the range 0.1 to 0.5 μf., a rectifier, means connecting said source through said rectifier to said capacitor to charge same, a radio-frequency voltage step-up transformer having a core of low loss ferro-magnetic material, a secondary-to-primary turns ratio of at least 50:1, a primary winding of between 10 and 40 turns and an inductance measured across the primary winding of 4 to 30 μh., make-and-break contacts, means connecting the primary winding of said transformer and the make-and-break contacts in series across said capacitor, a spark plug and means connecting the spark plug across the secondary winding of said transformer, the output from said source providing an inverse voltage across said rectifier of essentially 800 volts maximum.

2. An ignition system as claimed in claim 1, wherein the core of said transformer is of ferrite material.

3. An ignition system as claimed in claim 1, wherein said capacitor has a capacitance within the range of 0.15 to 0.3 μf.

4. An ignition system according to claim 1, wherein said turns ratio is at least 60:1.

5. A sub-assembly for use in an ignition system according to claim 1, the sub-assembly comprising a container, a low-frequency voltage step-up transformer in said container, said container also containing said rectifier, said capacitor and said radio-frequency transformer, the secondary winding of said low-frequency transformer being connected through said rectifier to said capacitor, and one plate of said capacitor being connected to one end of the primary winding of said radio-frequency transformer.

6. A sub-assembly according to claim 5, wherein the said container is of metal.

7. An ignition system for an internal combustion engine, comprising a source of alternating current, a capacitor having a capacitance within the range 0.15 to 0.3 μf., a rectifier, means connecting said source through said rectifier to said capacitor to charge same, a radio-frequency voltage step-up transformer having a core of ferrite material, a secondary-to-primary turns ratio of at least 60:1, a primary winding of between 10 and 40 turns and an inductance measured across the primary winding of 4 to 30 μh., make-and-break contacts, means connecting the primary winding of said transformer and said make-and-break contacts in series across said capacitor, a spark plug, and means connecting the spark plug across the secondary winding of said transformer, the output from said source providing an inverse voltage across said rectifier of essentially 800 volts maximum.

8. An ignition system for the spark plug of an internal combustion engine, comprising a source of alternating current, capacitor means having an effective capacitance essentially within the range 0.1 to 0.5 μf., charging means connecting said source to said capacitor means to charge same, voltage step-up transformer means having input means and output means, the effective inductance of said input means being essentially 4 to 30 μh., and means for discharging said capacitor means including make-and-break contact means, means operatively connecting the input means of said transformer means with said make-and-break contact means in series across said capacitor means, and means adapted to supply the voltage from the output means of said transformer means to the spark plug.

9. An ignition system for the spark plug of an internal combustion engine, comprising a source of alternating current, capacitor means having an effective capacitance essentially within the range 0.1 to 0.5 μf., rectifier means, means connecting said source through said rectifier means to said capacitor means to charge same, a voltage step-up transformer having input means and output means, said input means having essentially an inductance measured thereacross of essentially 4 to 30 μh., make-and-break contact means, means connecting the input means of said transformer means and the make-and-break contact means in series across said capacitor means, and means providing an ignition voltage for the spark plug from the output means of said transformer means.

10. An ignition system for the spark plug of an internal combustion engine, comprising a source of alternating current, capacitor means having a predetermined capacitance, rectifier means, means connecting said source through said rectifier means to said capacitor means to charge same, a radio-frequency voltage step-up transformer provided with input winding means and output winding means and having an effective output-to-input turns ratio of at least 50:1 and input winding means with essentially between 10 and 40 turns, make-and break contact means, means connecting the input winding means of said transformer and the make-and-break contact means in series across said capacitor means, and means providing an ignition voltage for the spark plug across the output winding means of said transformer.

11. An ignition system for an internal combustion engine, comprising a source of alternating current, capacitor means having a capacitance essentially within the range 0.1 to 0.5 μf., rectifier means, means connecting said source through said rectifier means to said capacitor means to charge same, a radio-frequency voltage step-up transformer provided with input winding means and output winding means and having a core of low loss ferromagnetic material, an effective output-to-input turns ratio of at least 50:1, input winding means essentially of between 10 and 40 turns and an inductance measured across the input winding means essentially of 4 to 30 μh., make-and-break contact means, means connecting the input winding means of said transformer and the make-and-break contact means in series across said capacitor means, spark plug means, and means connecting the spark plug means across the output winding means of said transformer, the output from said source providing an inverse voltage across said rectifier means of essentially 800 volts maximum.

12. An ignition system for the spark plug of an internal combustion engine, comprising a source of alternating

current, capacitor means having a predetermined capacitance, rectifier means, means connecting said source through said rectifier means to said capacitor means to charge same, a radio-frequency voltage step-up transformer provided with input winding means and output winding means and having an effective output-to-input turns ratio of at least 50:1 and input winding means with essentially between 10 and 40 turns, make-and-break contact means, means connecting the input winding means of said transformer and the make-and-break contact means in series across said capacitor means, and means providing an ignition voltage for the spark plug across the output winding means of said transformer, the output from said source providing an inverse voltage across said rectifier means of essentially 800 volts maximum.

13. An ignition system for the spark plug of an internal combustion engine, comprising a source of alternating current, capacitor means having a predetermined capacitance, rectifier means, means connecting said source through said rectifier means to said capacitor means to charge same, a radio-frequency voltage step-up transformer provided with input winding means and output winding means and having a core of low loss ferromagnetic material, an effective output-to-input turns ratio of at least 50:1 and input winding means with essentially between 10 and 40 turns, make-and-break contact means, means connecting the input winding means of said transformer and the make-and-break contact means in series across said capacitor means, and means providing an ignition voltage for the spark plug across the output winding means of said transformer.

14. An ignition system for the spark plug means of an internal combustion engine, comprising a source of alternating current, capacitor means having an effective capacitance essentially within the range 0.1 to 0.5 μf., rectifier means, charging means for charging said capacitor means through said rectifier means from said source, a radio-frequency voltage step-up transformer

having an effective secondary-to-primary turns ratio of at least 50:1, a primary winding of between 10 and 40 turns and an inductance measured across the primary winding of essentially 4 to 30 μh., make-and-break contact means, and output means including discharge means operatively connecting the primary winding of said transformer and the make-and-break contact means in series across said capacitor means to thereby provide an ignition voltage across the secondary winding of said transformer for said spark plug means upon discharge of said capacitor means.

15. An ignition system for the spark plug of an internal combustion engine, comprising a source of alternating current, capacitor means having a predetermined capacitance, rectifier means, means connecting said source through said rectifier means to said capacitor means to charge same, a radio-frequency voltage step-up transformer provided with input winding means an output winding means and having a core of low loss ferromagnetic material, an effective output-to-input turns ratio of at least 50:1 and input winding means with essentially between 10 and 40 turns, make-and-break contact means, means connecting the input winding means of said transformer and the make-and-break contact means in series across said capacitor means, and means providing an ignition voltage for the spark plug across the output winding means of said transformer, the output from said source providing an inverse voltage across said rectifier means of essentially 800 volts maximum.

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