United States Patent

[11] **3,595,212**

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[21] Appl. No. **799,688**
[22] Filed **Feb. 17, 1969**
[45] Patented **July 27, 1971**

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[32] Priority **Feb. 19, 1968**
[33] **Great Britain**
[31] **8020/68**

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[54] **SPARKING CIRCUIT FOR AN IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES**
3 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** ..... **123/148 E,** 315/180
[51] **Int. Cl.** **F02p 3/06**
[50] **Field of Search** ..... 123/148 E; 315/180, 182

[56] **References Cited**
UNITED STATES PATENTS

3,127,540	3/1964	Collins	315/180

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ABSTRACT: The invention concerns a sparking circuit for an ignition system for internal combustion engines comprising first and second discharge circuits, the first circuit being operatively associated with said second circuit via delay circuit means, discharge of the first circuit causing said second circuit to discharge after said first circuit but at less than 1 millisecond thereafter.

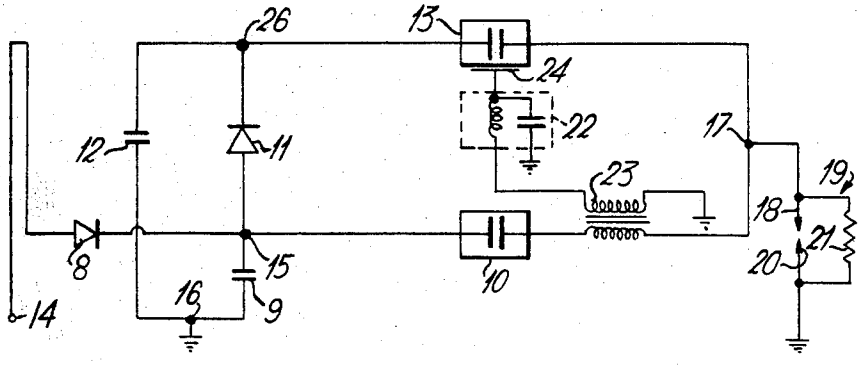


Fig 1

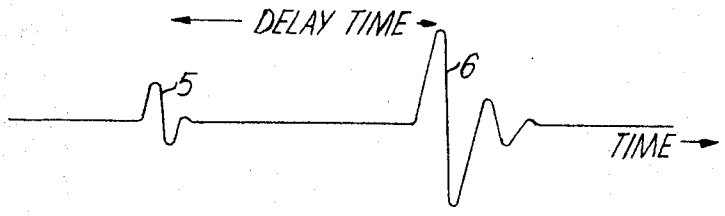


Fig 2

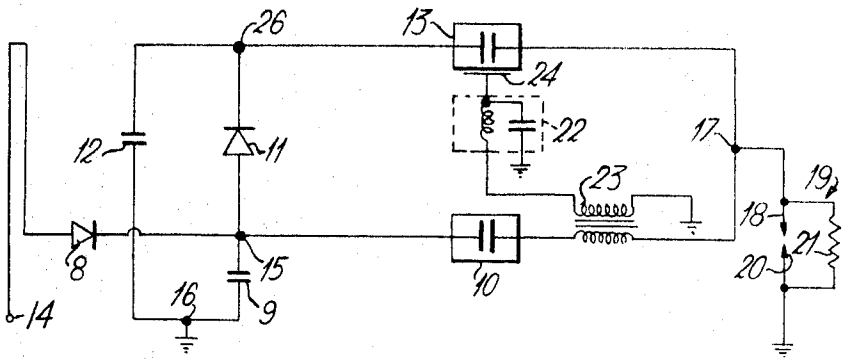
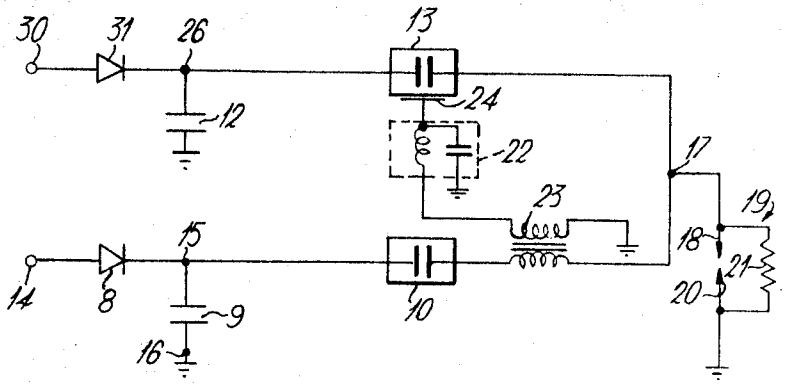


Fig 3



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SPARKING CIRCUIT FOR AN IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

This invention, which relates to a sparking circuit for an ignition system for internal combustion engines, is an improvement in or modification of the invention disclosed in our British Pat. No. 994,712.

In British Pat. No. 994,712 there is disclosed a sparking circuit for an ignition system for internal combustion engines which comprises first and second discharge circuits, said first discharge circuit being operatively associated with said second circuit via delay circuit means, so that in operation when said first circuit discharges it causes said second circuit to discharge between 1 and 40 milliseconds after said first circuit. In use, both said first and second circuits are connected to a sparking fuel igniter, such as a sparking plug, so that, in operation, said first and second circuits discharge between electrodes of said igniter.

The purpose of discharging the first circuit before the second circuit was to rupture any liquid fuel layer on the electrodes of the igniter, so that when the second circuit discharges, most of its energy is used in forming a spark between said electrodes. By arranging that the first circuit only discharges sufficient energy to rupture the liquid fuel layer normally found in operation on the igniter electrodes, the total energy dissipated per "spark" (i.e. the total energy dissipated by the first and second circuits), can be less than with a conventional sparking system in which a single electrical power pulse is applied between the igniter electrodes.

In the case of the sparking circuit of British Pat. No. 994,712, however, the "leader spark" produced by the first discharge circuit merely blasted fuel off the electrodes so that the "main spark" produced by the second discharge circuit could subsequently effect ignition of fuel supplied to the combustion chamber in the normal way.

We have now found, however, that significantly improved results are obtained if the second circuit discharges less than one millisecond after the first circuit, since the fuel blasted off by the leader spark will then be immediately ignited by the main spark, thus setting up a "travelling flame" which ignites the fuel supplied to the combustion chamber.

According therefore to the present invention, there is provided a sparking circuit for an ignition system for internal combustion engines comprising first and second discharge circuits, the first circuit being operatively associated with said second circuit via delay circuit means, so that in operation when said first circuit discharges, it causes said second circuit to discharge after said first circuit but at less than 1 millisecond thereafter.

Preferably the second circuit discharges between 250 and 750 microseconds after said first circuit.

First and second charging means may be provided for effecting separate charging of the first and second discharge circuits, whereby, when desired, one only of the said circuits may be charged.

The first and second charging means are preferably such that the discharge pulses produced thereby are of substantially equal energy.

The invention is illustrated merely by way of example, in the accompanying drawings, in which:

FIG. 1 shows two successive electrical current pulses produced by a sparking circuit according to the invention,

FIG. 2 shows a circuit diagram of a sparking circuit according to the invention, and

FIG. 3 shows a circuit diagram of a modified sparking circuit.

The two pulses 5, 6 of FIG. 1, when they pass between the electrodes of a sparking fuel igniter, serve respectively to produce a leader spark which blasts off any liquid fuel on the igniter electrodes, and a main spark which effects immediate ignition of this blasted off fuel and therefore sets up a travelling flame which ignites the fuel supplied to the combustion chamber. The pulse 6 occurs after the pulse 5 but at less than 1 millisecond (and preferably between 250 and 750 microseconds thereafter) and the maximum amplitude of the pulse 5 as illustrated is smaller than and approximately half that of pulse 6.

In one case using an igniter of the recess gap type, (i.e. an igniter having a hollow outer electrode, an inner electrode which is flush with the end of the outer electrode, and semiconductor material which is disposed in a recess between the electrodes) liquid fuel was displaced satisfactorily from the igniter electrodes when the energy of pulse 5 had a minimum value of 0.4 joules. For a flush fire type of igniter (i.e. an igniter in which both the electrodes and the semiconductor material are flush) less energy would be necessary for displacing liquid fuel satisfactorily from the igniter electrodes.

The invention is particularly applicable, however, to the recess gap type igniter since the recess of the latter holds more fuel than collects on a flush fire type of igniter, and a bigger travelling flame can therefore be produced.

The sparking circuit shown in FIG. 2 comprises a first spark generating circuit which includes a rectifier 8, a condenser 9 and a low pressure gas discharge tube 10, and a second spark generating circuit which includes a rectifier 11, a condenser 12 and a low pressure gas discharge tube 13. The breakdown voltage of the tube 13 is preferably greater than that of tube 10. The rectifier 8 is connected to an H.T. alternating or pulsating supply 14, and between a circuit point 15 and an earth connection 16 is connected condenser 9. The rectifier 11 is connected between circuit points 15 and 26, while the condenser 12 is connected between circuit point 26 and the earth connection 16. Both the first and second circuits are connected together at circuit point 17, which is connected in turn to an electrode 18 of a sparking fuel igniter 19, the igniter 19 having a second electrode 20 which is connected to earth, and also the electrode 18 via means 21 providing a very high resistance, such as a semiconductor.

The first circuit is operatively associated with the second circuit via delay circuit means comprising an electromagnetic coupling in the form of a transformer 23, and a delay circuit 22. The circuit 22 is connected to an electrode 24 of the gas discharge tube 13, the electrode 24 being arranged externally of the tube and intermediate its two other electrodes which are connected in the second circuit.

In operation, when the H.T. supply is switched on, both condensers 9, 12 charge through the rectifier 8, the conden ser 12 in addition charging through the rectifier 11. Condenser 12 has a considerably greater capacity than the condenser 9. The voltages at circuit points 15 and 26 progressively rise, and when the voltage across the gas discharge tube 10 reaches the breakdown voltage thereof, the condenser 9 discharges through the tube 10, the primary winding of transformer 23, and across the electrodes 18, 20 of the igniter. This pulse is the pulse 5 (FIG. 1) and serves to produce the said leader spark which blasts off fuel on the electrodes 18, 20. It will be noted that the rectifier 11 prevents the condenser 12 discharging through the tube 10 when the latter is conducting. The current pulse flowing through the primary winding of the transformer 23 causes a voltage pulse to appear on the electrode 24 after a delay determined by the transformer 23 and the delay circuit 22, the transformer 23 contributing to the delay which is less than 1 millisecond. This voltage pulse causes the tube 13 to become conducting, and the condenser 12 discharges through the tube 13 and forms the said main spark between the electrodes 18, 20 of the igniter. The current pulse occurring in the second circuit when the main spark is formed is the pulse 6 (FIG. 1).

The modified sparking circuit shown in FIG. 3 is generally similar to that of FIG. 2 and for this reason will not be described in detail, like reference numerals indicating like parts.

In the FIG. 3 sparking circuit, however, the condenser 12, instead of being charged from the H.T. supply 14 through the rectifiers 8 and 11, is charged from a separate H.T. supply 30 through a rectifier 31. Thus the said first and second circuits

are charged by separate charging means, the arrangement being such that both the sparks produced thereby are of equal energy, e.g. 6 joules.

Accordingly, in the case of the FIG. 3 construction, both the H.T. supplies **14, 30** are employed for normal starting. For continuous starting, however, e.g. starting in flight and with the engine warm, only the H.T. supply **14** is employed.

I claim:

1. A sparking circuit for use in the ignition system of an internal combustion engine, said circuit comprising:

a first discharge circuit means for producing a leader spark used to blast liquid fuel away from sparking electrodes in a combustion chamber of said engine,

a second discharge circuit means for producing a main spark used to ignite fuel in said chamber while it is set in motion by said leader spark thereby setting up a travelling flame in said combustion chamber,

said first and second discharge circuit means each comprising a rectifier, a condenser and a discharge tube, and

a third circuit means including delay means and operatively connected between said first and second circuit means for triggering discharge of said second circuit, after a time delay, from the discharge of said first circuit wherein discharge of said first circuit energizes said third circuit which, in turn, causes said second circuit to discharge between approximately 250 and 750 microseconds after said first circuit.

2. A sparking circuit as claimed in claim **1** in which first and second charging means are provided for effecting separate charging of the first and second discharge circuits, whereby, when desired, one only of the said circuits may be charged.

3. A sparking circuit as claimed in claim **2** in which the first and second charging means are such that the discharge pulses produced thereby are of substantially equal energy.