United States Patent [19]
Kammerer et al.
[11] 3,782,353
[45] Jan. 1, 1974

[54] CAPACITIVE TYPE IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES

[75] Inventors: **Heinz Kammerer**, Nellingen; **Heinz Moller**, Stuttgart, both of Germany

[73] Assignee: **Robert Bosch GmbH**, Stuttgart, Germany

[22] Filed: **Sept. 30, 1971**

[21] Appl. No.: **185,162**

[30] **Foreign Application Priority Data**
Oct. 6, 1970 Germany .... P 20 48 960.5

[52] **U.S. Cl.** .... **123/148 E,** 123/148
[51] **Int. Cl.** **F02p 1/00**
[58] **Field of Search** .... 123/148 E

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

3,312,860	4/1967	Strum	123/148 E
3,372,681	3/1968	Phillips	123/148 E
2,847,489	8/1958	Short	123/148 E
3,504,658	4/1970	Chauls	123/148 E
3,465,738	9/1969	Gerlach	123/148 E
3,045,148	7/1962	McNulty	123/148 E
2,392,192	1/1946	Robinson	123/148 E
3,331,362	7/1967	Mitchell	123/148 E
3,489,129	1/1970	Issler	123/148 E
3,316,449	4/1967	Quinn	123/148 E

Primary Examiner—Laurence M. Goodridge
Assistant Examiner—Ronald B. Cox
Attorney—Michael S. Striker

[57] **ABSTRACT**

Energy from a storage capacitor is transferred to an ignition capacitor when a first switch is made conductive, and the spark is initiated by discharge from the ignition capacitor through the ignition transformer upon closing of a second switch. The current limiting element between the storage capacitor and the ignition capacitor is an inductance.

9 Claims, 3 Drawing Figures

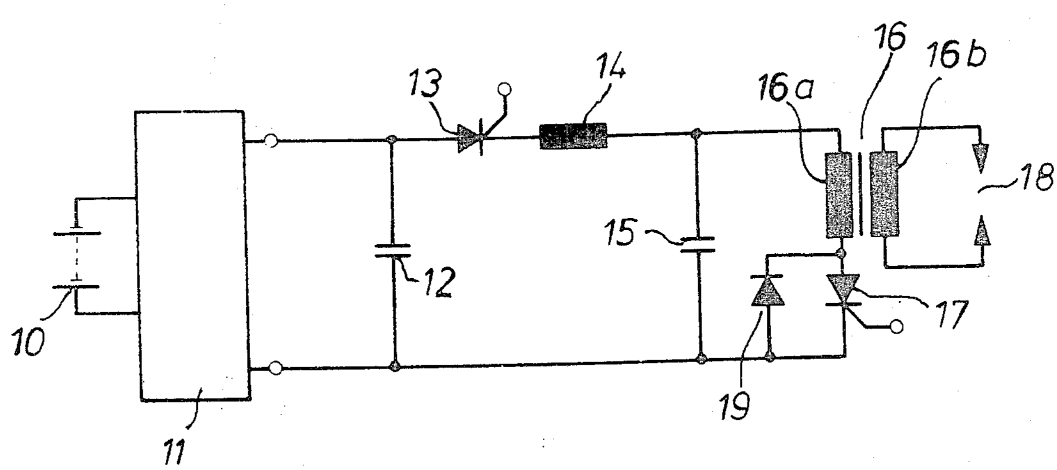


Fig.1

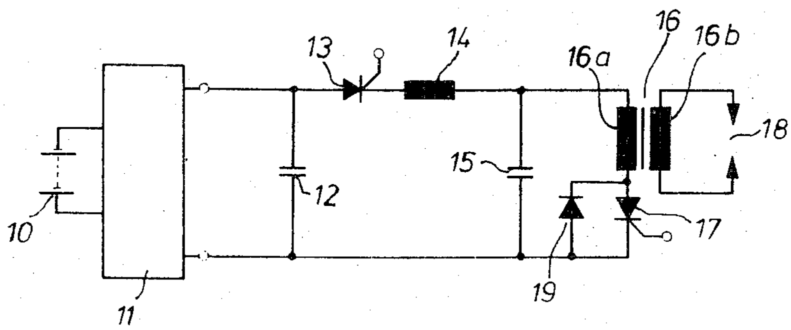
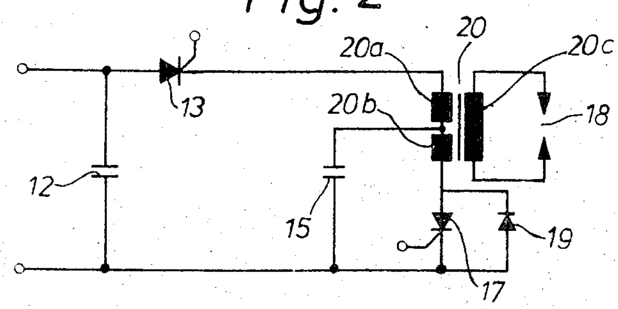


Fig. 2



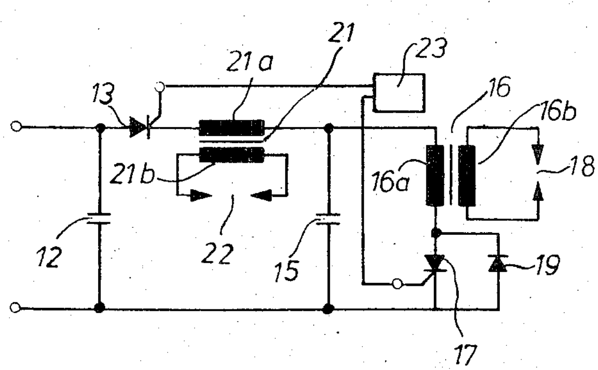


Fig. 3

CAPACITIVE TYPE IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates to ignition arrangements for internal combustion engines. In particular, it relates to such ignition arrangements wherein the storage capacitor is connected to an ignition capacitor by means of a switching element and a current limiting element. Further, the ignition capacitor is connected to an ignition transformer, more specifically the primary winding of the ignition transformer via a second switch, while the secondary winding of the ignition transformer is connected to at least one spark plug. The two switch elements are activated alternatingly.

A known arrangement of this type operates to generate a plurality of sequential sparks. Specifically, a storage capacitor is charged from a battery through a D.C. power supply. The energy stored in the storage capacitor is transferred to the ignition capacitor through the current limiting element when the first switch means are in the conductive state. The current limiting impedance is a resistance. At the desired ignition time, the ignition capacitor is discharged through the primary of the ignition transformer thereby inducing a spark in the spark plug or in other spark generating element in the secondary winding. The primary winding of the ignition transformer does not load the power supply, since at the time the second switch is closed, the first switch is opened.

The above-described ignition arrangement has the disadvantage that each transfer energy from the storage capacitor to the ignition capacitor causes a loss of the energy in the current limiting resistance. Thus the efficiency of such an arrangement is very low. Such an arrangement is only functional when a D.C. power supply of high power output at a high voltage is used.

SUMMARY OF THE INVENTION

It is an object of the present invention to improve the efficiency of the above-described ignition arrangement, thereby decreasing the necessity for a high supply voltage by utilization of the available energy.

The present invention comprises storage capacitor means and ignition capacitor means. An ignition transformer has a primary and a secondary winding. The secondary winding of the ignition transformer is connected to spark generating means, while its primary winding is connected in parallel with the ignition capacitor through second switch means, when said second switch means are in the conductive state. The ignition capacitor is connected to the storage capacitor through first switch means. The current limiting element connected in series with the first switch means comprise an inductance.

The use of the inductance causes almost lossless transfer of energy between the storage and the ignition capacitor. Further, the presence of the inductance causes a resonant voltage rise across the capacitor, so that the voltage available across the primary winding of the ignition transformer at ignition time is substantially higher than the voltage existing across the storage capacitor. With appropriate design of the ignition transformer and the inductance, the ignition arrangement may be directly connected to the battery, without use of a D.C. power supply.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to the construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments when read in connection with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 shows an ignition arrangement in accordance with the present invention, wherein an inductance is used;

FIG. 2 shows an ignition arrangement wherein a second primary winding of the ignition transformer serves as current limiting element; and

FIG. 3 shows an ignition arrangement wherein the primary winding of a second ignition transformer serves as inductive impedance in the energy transfer circuit between the storage and the ignition capacitor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred embodiment of the present invention will now be described with reference to the drawing.

The source of energy for the ignition arrangement shown in FIG. 1 is a battery **10** which is connected to a D.C. power supply stage **11.** The output of this stage is connected to a storage capacitor **12** of 100 microfarads. It is further connected with first switch means, here a thyristor **13.** Connected in series with thyristor **13,** is an inductive impedance **14** and an ignition capacitor **15** of one microfarad. The primary winding **16*a*** of an ignition transformer **16** is connected in parallel with ignition capacitor **15** via second switch means, namely a thyristor **17.** A spark plug **18** is connected to the secondary winding **16*b*** of the ignition transformer **16.** The spark plug **18** is of course located in a cylinder of the internal combustion engine, which is not shown. A diode **19** is connected, with opposing polarity, in parallel with thyristor **17.**

In this arrangement, capacitor **12** is constantly charged to the output voltage of stage **11.** When thyristor **13** becomes conductive through a control voltage applied at its gate, a part of the electrical energy stored in storage capacitor **12** is transferred through thyristor **13** and inductance **14** to the ignition capacitor **15.** The inductive impedance **14** in series with ignition capacitor **15** forms a series-resonant circuit, thus causing the voltage across the capacitor **15** to exceed the voltage across capacitor **12.** At this time the current through the circuit goes to zero, blocking thyristor **13.** At the ignition time, the second switch, thyristor **17,** becomes conductive causing the energy stored in ignition capacitor **15** to be discharged through the primary winding **16*a*** of ignition transformer **16** and thyristor **17.** This causes a high voltage pulse to be induced in the secondary winding of ignition transformer **16,** which in turn causes a spark to be generated at spark plug **18.** The energy which is not utilized in the spark is returned to capacitor **15** with reverse polarity, since ignition capacitor **15** and ignition transformer **16** form a resonant circuit. When the current of this resonant circuit passes through zero, the remaining energy is completely stored in capacitor **15** and the second thyristor **17** blocks. Because of diode **19** which has the inverse polarity to thyristor **17,** the energy stored in the capacitor is again available to primary coil 16*a*, thus causing the spark at spark plug **18** to continue past its otherwise existing time period. The length of the spark is almost doubled.

Inductive impedance **14** together with diode **19**, effect automatic regulation of the required primary voltage. For example, if a great deal of energy is required for the spark, the remaining energy stored in ignition capacitor **15** is small and the voltage difference appearing between the two terminals of inductive impedance **14** at the beginning of the next energy transfer between capacitors **12** and **15**, is low. Thus, during the next energy transfer, the voltage at the ignition capacitor **15** greatly exceeds the supply voltage across capacitor **12**, so that a high voltage is available for the next ignition, thus supplying a higher energy to the next ignition. However if an ignition process requires only little energy, the remaining voltage on capacitor **15** remains relatively large, causing the voltage difference at the two terminals of inductive impedance **14** to be small, so that the voltage across ignition capacitor **15** does not exceed the supply voltage by much. Thus a small amount of electrical energy is transferred from storage capacitor **12** to ignition capacitor **15.** Such automatic regulation is particularly desirable when a series of sparks is to be generated in rapid sequence, since it insures reliable ignition of the fuel-air mixture in the cylinder and a high efficiency of the engine.

The capacitance of storage capacitor **12** greatly exceeds the capacitance of ignition capacitor **15.** It may be exceeded by much more than a factor of **10.** This causes the charging of each ignition capacitor to cause only a partial discharge of the storage capacitor, and therefore keeps the losses generated in stage **11** during the charging of the storage capacitor at a minimum. Low losses result when the voltage at the storage capacitor **12** is a maximum prior to charging, thus causing little charging current to flow through stage **11**, keeping the losses in the stage generated by its internal impedance at a minimum.

The circuit of FIG. **2** will now be discussed. Elements which correspond to the elements of FIG. **1** have the same reference numeral. The difference between the circuit of FIG. **2** and that of FIG. **1** is that the inductive impedance **14** is replaced by a second primary winding **20*a*** of the ignition transformer which is labelled **20** in FIG. **2.** The ignition transformer has a first primary winding **20*b*** which is connected to ignition capacitor **15** via a thyristor **17** as in FIG. **1.** However, as stated above, the second primary winding **20*a*** is connected to the cathode of thyristor **13** on one end, and to ignition capacitor **15** at the other end. The secondary winding **20*c*** of the ignition capacitor is again connected to spark plug **18.**

In the arrangement of FIG. **2,** a spark is generated at spark plug **18** both when energy is transferred from capacitor **12** to capacitor **15,** and when capacitor **15** is discharged through winding **20*b*.** Thus in this particular case, thyristors **13** and **17** are alternatingly put into the conductive condition at the ignition time. Here, too, the diode **19** connected in parallel with thyristor **17,** but with opposite polarity, effects automatic regulation of the required ignition voltage. This is the case since, here, too, energy remaining on capacitor **15** after one ignition, causes less energy to be drawn from storage capacitor **12** prior to the subsequent ignition. The main advantage of this ignition arrangement relative to that of FIG. **1** is that the losses during transfer from capacitor **12** to capacitor **15,** are only half of those of the arrangement of FIG. **1,** since the frequency of energy transfer is half that of FIG. **1.**

FIG. **3** shows another preferred embodiment of the present invention. Again, the components in FIG. **3** which are the same as those of FIGS. **1** and **2,** have the same reference numbers. In the arrangement of FIG. **3,** a second ignition transformer, **21,** is present. The primary winding, **21*a*,** of ignition transformer **21,** is the inductive impedance connected in series with thyristor **13.** The secondary winding **21*b*** of the ignition transformer **21** also has a spark plug connected thereto. The ignition arrangement of FIG. **3** operates similarly to that of FIG. **2.**

Thyristors **13** and **17** are switched alternatingly to the conductive state, each at the ignition time. The control of thyristors **13** and **17** may take place by a control voltage furnished at the respective gates by means **23** — shown in FIG. **3** — such as a multivibrator or a magnetic pulse generator. The spark frequency of the arrangement according to FIGS. **2** and **3** is twice as high as that of FIG. **1.** In the arrangements of FIGS. **2** and **3,** the diode **19** does not serve to lengthen the pulse which is generated at the time of energy transfer between capacitors **12** and **15,** since it is effective only upon discharge of the ignition capacitor through the primary winding of the ignition transformer. Thus diode **19** in arrangements of FIGS. **2** and **3,** is only effective for every alternate spark. However, this is very advantageous in double-spark or multi-spark ignition arrangements, since the first spark may be made particularly short and of high energy by means of an appropriate design of the primary winding **20*a*** or **21*a*.** The second spark is then made substantially longer and weaker by a corresponding design of the primary windings **20*b*** and **16*a*.**

It is also within the scope of this invention that diode **19** can be omitted, thus causing all the sparks to be of equal strength and duration.

While the invention has been illustrated and described as embodied in a capacitive type ignition arrangement for internal combustion engines, it is not intended to be limited to the details shown, since various modifications, structural and circuit changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fairly constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the following claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims:

1. In an internal combustion engine, an ignition arrangement, comprising, in combination, storage capacitor means; ignition capacitor means; first switch means connecting said storage capacitor means to said ignition capacitor means when in a conductive state; first ignition transformer means having a primary winding connected in series to said first switch means and a secondary winding; first spark generating means connected to said secondary winding; second ignition transformer means having a primary winding and a secondary winding; second spark generating means connected to said secondary winding; and second switch means connecting said primary winding of said second transformer means in parallel with said ignition capacitor means when said second switch means is in a conductive state.

2. In an internal combustion engine, an ignition arrangement, comprising, in combination, storage capacitor means; ignition capacitor means; first switch means connecting said storage capacitor means to said ignition capacitor means when in a conductive state; ignition transformer means having a first primary winding connected in series to said first switch means, a second primary winding, and a secondary winding; and second switch means connecting said second primary winding to said ignition capacitor means when said second switch means is in a conductive state.

3. In an internal combustion engine, an ignition arrangement, comprising, in combination, storage capacitor means having a first and second terminal; ignition capacitor means having a first terminal directly connected to said first terminal of said storage capacitor means and a second terminal; first switch means connecting said second terminal of said storage capacitor means to said second terminal of said ignition capacitor means when in a conductive state; inductive impedance means series-connected to said first switch means; ignition transformer means having a primary winding and a secondary winding; spark generating means connected to said secondary winding; and second switch means connecting said primary winding in parallel with said ignition capacitor means when said second switch means is in a conductive state.

4. An arrangement as set forth in claim 3, further comprising means alternatingly switching said first and second switch means to said conductive state.

5. An arrangement as set forth in claim 3, wherein said second switch means comprise a thyristor.

6. An arrangement as set forth in claim 5, further comprising diode means connected, with opposing polarity, in parallel with said thyristor.

7. An arrangement as set forth in claim 3, wherein said first switch means comprise a thyristor.

8. An arrangement as set forth in claim 3, wherein the capacitance of said storage capacitor substantially exceeds the capacitance of said ignition capacitor means.

9. An arrangement as set forth in claim 8, wherein the capacitance of said storage capacitor means is more than ten times the capacitance of said ignition capacitor means.

* * * * *