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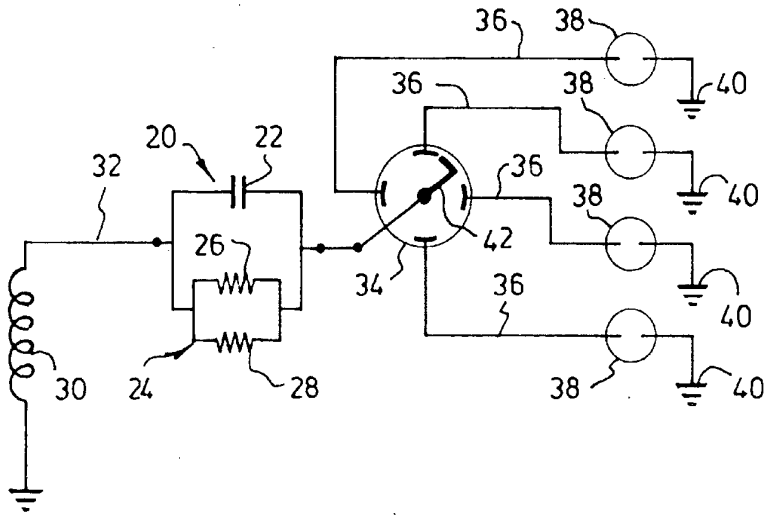

(57) Abstract

An electrical circuit for inclusion in the high tension circuit of the ignition system of a spark ignition engine, the electrical circuit being characterised by comprising a capacitor having in parallel therewith a resistance having a value lying in the range from 15 k ohms to 50 k ohms, thus strengthening the capacitive and shortening the inductive discharge phase of a spark.

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IGNITION CIRCUIT HAVING DEVICE TO SHORTEN INDUCTIVE DISCHARGE PHASE OF A SPARK EVENT

The present invention relates to electrical circuits for use with spark ignition internal combustion engines.

In co-pending PCT/GB91/01928 of common ownership herewith, we describe the use of capacitors in combination with other electrical devices in the spark ignition circuits of internal combustion engines. A conventional spark broadly comprises two constituent parts; a first part consisting of a relatively high current, short duration "bright-line" spark discharge, often referred to as the capacitive discharge phase; and a second part consisting of a lower current, longer duration glow discharge or "flaring" discharge, often referred to as the inductive discharge phase. The bright-line discharge is a high temperature spark, and lasts for a relatively small proportion of the total spark time and which although it constitutes the means by which the combustion event is initiated, produces only a relatively small quantity of heat. The flaring discharge phase, is on the other hand, a relatively lower temperature discharge, but lasts for the greatest portion of the total spark duration time, and produces a relatively high quantity of heat compared to the bright-line discharge.

We have found that the flaring discharge is associated with harmful effects, both on engine components and on the combustion quality per se. The relatively high heating effect of this part of the spark causes premature erosion of the spark plug electrodes, thus unnecessarily shortening the life of the spark plugs, and contributes to unnecessarily high exhaust gas emissions. We believe that the spark plug electrode erosion is attributable to the flaring discharge heating the electrodes to a temperature substantially above that consequent on the effects of the combustion event per se. Furthermore, we believe that the long duration, lower temperature flaring discharge part of the spark promotes undesirable chemical reactions in the fuel charge during the combustion event, resulting in unnecessarily high exhaust emission levels.

However, we have now found that the beneficial effects of the invention as described in our co-pending PCT/GB91/01928 may be substantially further improved by removing only a controlled portion of the flaring discharge part of the spark. We have now found that if too much of the flaring discharge is removed from the spark event, then a proportion of the available improvement in engine performance is sacrificed, whilst if too little is removed, then the improvement in engine performance is not so great as may be achieved.

Whilst it is not possible to quantify an absolute "amount" of the flaring discharge which should desirably be removed, since this will vary from one engine and ignition system combination

to another, it is possible now to define more closely the electrical circuit and the values of the electrical components within that circuit which will give a substantial improvement in engine performance.

According to the present invention there is provided an electrical circuit for inclusion in the high tension circuit of the ignition system of a spark ignition engine, the electrical circuit comprising a capacitor having in parallel therewith a resistance having a value lying in the range from 15k ohms to 50k ohms.

Preferably, the resistance may lie in the range from 27k ohms to 36k ohms.

A more preferred range still is 27k ohms to 31k ohms.

We have found that if the value of the resistance lies below 15k ohms, then the degree of shortening of the flaring part of the spark becomes too small. Conversely, if the value of the resistance lies substantially above 50k ohms, then the degree of shortening of the flaring part of the spark is too great and the overall improvement in engine performance is not so great as may be achieved.

Furthermore, we believe that if too much of the flaring part of the spark is removed then ignition timing tolerances may

become too small. If the engine ignition timing is set incorrectly, then a very short duration spark may not coincide with the optimum compression condition of the fuel charge in the engine cylinder and a misfire may occur. To ensure reliable ignition of the fuel charge, we believe that a minimum spark duration time of about 0.6 ms may be required.

The preferred range of 27k ohms to 36k ohms may produce the optimum balance of effects over a wide range of vehicles, including older vehicles and brand new vehicles.

Furthermore, if the resistance value is too high, it is possible for the ignition circuit to adopt an AC operating mode which can have undesirable effects on some electrical instruments in the vehicle. To remove the AC mode of operation in these circumstances, it is necessary to incorporate a diode into the circuit which adds to the cost thereof. Therefore, by keeping the resistance to the range specified, operation in an AC mode is precluded.

In a preferred embodiment of the present invention, the resistance of 15k ohms to 50k ohms may be provided by two resistances in parallel. For example, if it is intended to use a total resistance of 27k ohms, this resistance may be provided in the form of two 54k ohm resistances connected in parallel. This has been found to be beneficial in that the maximum temperature reached by the resistance elements is considerably reduced thus extending component life. Furthermore, the use of

two resistances allows the use of resistances having lower power capability ratings thus making manufacture of the circuit more economic. Resistors having ratings of 9W or 12W have been found to be entirely suitable.

An advantage of having two or more resistances connected in parallel to provide the required total resistance is that the thermal capacity of the circuit, and the device embodying the circuit, is increased leading to enhanced stability and life.

The number of resistances connected in parallel may be limited by practical considerations of availability or space, weight and cost rather than by purely technical considerations.

Where the resistance is provided in the form of two or more resistances in parallel, it is not necessary that the resistances be of equal values, only that the total effective resistance lies within the required range.

Preferably, the resistances are wire-wound resistors in the interests of reliability and longevity.

The capacitor may have a value lying within the range from 500pF to about 5000pF. Capacitors take a finite time to charge, the time taken being related to the capacitance value. The higher the capacitance, the longer is the time required to charge. An engine operates over a wide speed range from tickover, at about 800 rev/min up to about 6500 rev/min for

"normal" road vehicles. In order to cater for all types of coil outputs and conditions, a capacitance in the range from 1000pF to 2500pF is preferred.

Two or more of the electrical circuits according to the present invention may be connected in series in the high tension circuit of an ignition system.

In order that the present invention may be more fully understood, an example will now be described by way of illustration only with reference to the accompanying drawings, of which:

Figure 1 shows a graph of current vs time for an ignition spark event;

Figure 2 shows an electrical circuit according to the present invention;and

Figure 3 which shows a schematic diagram of a vehicle spark ignition circuit having an electrical circuit of the present invention therein.

Referring now to the drawings, and where the same features are denoted by common reference numerals.

Figure 1 illustrates the current/time relationship in a single spark produced by a conventional ignition system. The spark

comprises two basic parts; an initial bright-line capacitive discharge at the beginning of the spark event indicated to the left of the line 10 on the "t" axis; and a second flaring, inductive discharge indicated between the lines 10 and 12 on the "t" axis.

Figure 2 shows an example of an electrical circuit 20 according to the present invention. The circuit comprises a capacitor 22 having a value of 2200pF and a resistance 24 in parallel therewith, the resistance having a value of 31k ohms. The resistance 22 itself comprises two wire-wound resistors 26, 28 connected in parallel and each of 62k ohms resistance. The effect of connecting the two resistors in parallel is to give a total resistance of half their individual values, ie 31k ohms.

Figure 3 shows the electrical circuit 10 of Figure 2 connected into a conventional spark ignition system which comprises an induction coil 30 connected by a high tension lead 32 to a distributor 34 which is itself connected by leads 36 to spark plugs 38 which are earthed 40 in a cylinder head (not shown) of an engine (not shown).

The effect of the circuit 10 is to allow the initial high voltage breakdown pulse produced by the coil 30 through to the relevant spark plug 38 depending upon the position of the rotor arm 42 in the distributor 34. This initial high voltage pulse produces the bright-line spark indicated to the left of line

10 in Figure 1. The remainder of the spark cycle produced by the coil 30 corresponds to the flaring part of the spark cycle. This part is of a lower frequency and is attenuated by the circuit 20. Therefore, the remainder of the spark pulse must go through the resistance 24. The effect of this is to remove some of the spark pulse energy which would form the flaring part of the spark indicated between the lines 10 and 12 in Figure 1, the removed energy being dissipated as heat in the resistance 24, thus shortening the second part of the spark event. The effect of the circuit 24 is to filter out that part of the spark event which is not required.

The effect of the circuit 20 of the present invention is shown qualitatively in Figure 1 where for resistances of less than 15k ohms the position of the line 14 is displaced to the right, ie diminishing the amount of the flaring part of the spark which is removed. Where the value of the resistance 24 is greater than 50k ohms, the line 16 is displaced to the left, ie increasing the amount of the flaring part of the spark which is removed. The dashed lines 18 and 19 qualitatively indicate the extent of the spark duration with resistances 24 of 15k ohms and 50k ohms, respectively.

Two or more of the circuits 20 may be connected in series in an ignition system to provide a cascade effect. The high frequency, bright-line part of the spark passes through the capacitances of the circuits unaffected, whilst the lower frequency, flaring part of the spark passes through the

resistances 24 which are in series. Thus, more of the flaring part of the spark event is filtered out by the circuits when connected in series in this manner.

Although the present invention has been described with reference to the fitting of a single (or two or more) circuit(s) 20 between the coil and distributor, such circuits may be fitted in each individual plug lead 36 between the distributor and spark plugs.

CLAIMS

1. An electrical circuit for inclusion in the high tension circuit of the ignition system of a spark ignition engine, the electrical circuit being characterised by comprising a capacitor having in parallel therewith a resistance having a value lying in the range from 15k ohms to 50k ohms.

2. An electrical circuit according to claim 1 characterised in that the value of the resistance lies in the range from 27k ohms to 36k ohms.

3. An electrical circuit according to claim 1 characterised in that the value of the resistance lies in the range from 27k ohms to 31k ohms.

4. An electrical circuit according to any one preceding claim characterised in that the value of the capacitor lies in the range from 500 pF to 5000 pF.

5. An electrical circuit according to claim 4 characterised in that the value of the capacitor lies in the range from 1000 pF to 2500 pF.

6. An electrical circuit according to any one preceding claim characterised in that the resistance is provided by at least two resistances connected together in parallel.

7. An electrical circuit according to claim 6 characterised in that the resistances are of unequal values.

8. An electrical circuit according to any one preceding claim characterised in that the resistance(s) is a wire-wound resistor.

9. An electrical circuit according to any one preceding claim characterised in that the resistor has a power rating of 9W or above.

10. An electrical circuit according to any one preceding claim characterised in that the resistance has a value of 31k ohms and the capacitor has a value of 2200 cF.

11. An electrical circuit according to claim 10 characterised in that the resistance of 31k ohms comprises two resistances each of 62k ohms connected in parallel.

12. An ignition system for a vehicle characterised by having an electrical circuit according to any one of preceding claims 1 to 11.

13. An ignition system for a vehicle according to claim 12 characterised in that said circuit is placed between a high voltage source and a distributor in said system.

14. An ignition system according to claim 12 characterised in that said circuit is placed between a distributor and each spark plug.

15. An ignition system according to either claim 12 or claim 13 characterised in that there are two or more of said circuits in series with each other.

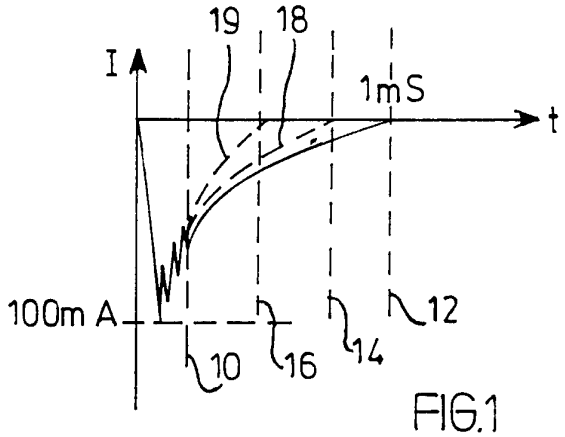

FIG.1

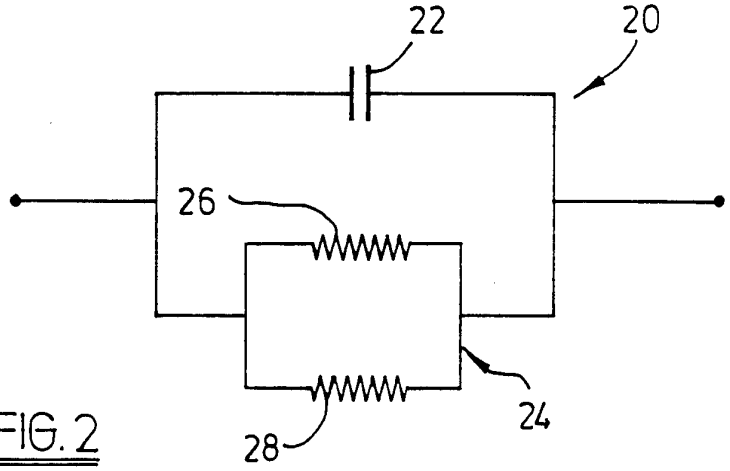

FIG. 2

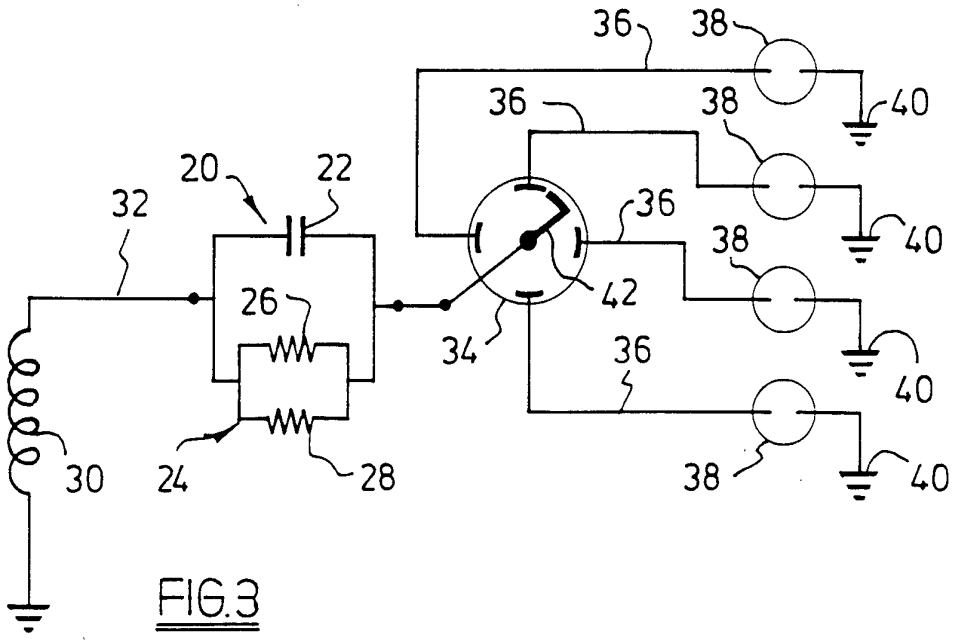

FIG.3

INTERNATIONAL SEARCH REPORT

Inter. .onal Application No
PCT/GB 94/00175

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 F02P9/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 5 F02P H01T

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO,A,92 08048 (DAWSON ROYALTIES LIMITED) 14 May 1992 cited in the application see the whole document ---	1,4,5, 12-15
A	US,A,5 168 858 (MONG) 8 December 1992 see abstract; figures ---	1,12-15
A	EP,A,0 147 613 (ROBERT BOSCH GMBH) 10 July 1985 see page 6, line 5 - line 30; figure 1 ---	1
A	PATENT ABSTRACTS OF JAPAN vol. 4, no. 29 (M-002)14 March 1980 & JP,A,55 005 461 (SUZUKI NOBORU) 16 January 1980 see abstract ---	
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[X] Further documents are listed in the continuation of box C.

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A	PATENT ABSTRACTS OF JAPAN vol. 16, no. 370 (M-1292)10 August 1992 & JP,A,04 116 268 (RYODA SATO) 16 April 1992 see abstract -----	

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Information on patent family members

Int. onal Application No
PCT/GB 94/00175

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		GB-A-	2264980	15-09-93
		JP-T-	6502468	17-03-94
US-A-5168858	08-12-92	NONE		
EP-A-0147613	10-07-85	DE-A-	3347027	04-07-85
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		US-A-	4613789	23-09-86