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(71) Applicant: DUCATI ENERGIA S.p.A.
I-40132 Bologna (IT)

(72) Inventors:
- Venturoli, Alessandro
I-40134 Bologna (IT)
- Gabrielli, Christian
I-40137 Bologna (IT)

(74) Representative: Coloberti, Luigi
Via E. de Amicis No. 25
20123 Milano (IT)

(54) Method and apparatus for setting the timing of the ignition system of an internal combustion engine

(57) A method and an apparatus for setting the timing of the ignition system (CDI) of an internal combustion engine (M); after checking the timing of the ignition circuit (CDI) with the engine (M) running at a predetermined speed, and determining the amount of the correction to be performed for the advance, the engine (M) is stopped and the active setting of the ignition (CDI) is modified on the basis of a coded correction procedure stored in a setting unit (21) detachably connected between the voltage generator (10, 12, 13) and the ignition system (CDI), by sending timing correction signals to a control processor (PC) of the ignition system (CDI) via the same lines (RL1÷RL4) which normally connect the timing pick-up (13) and the feed coil (12) of the voltage generator, to the ignition circuit (CDI).

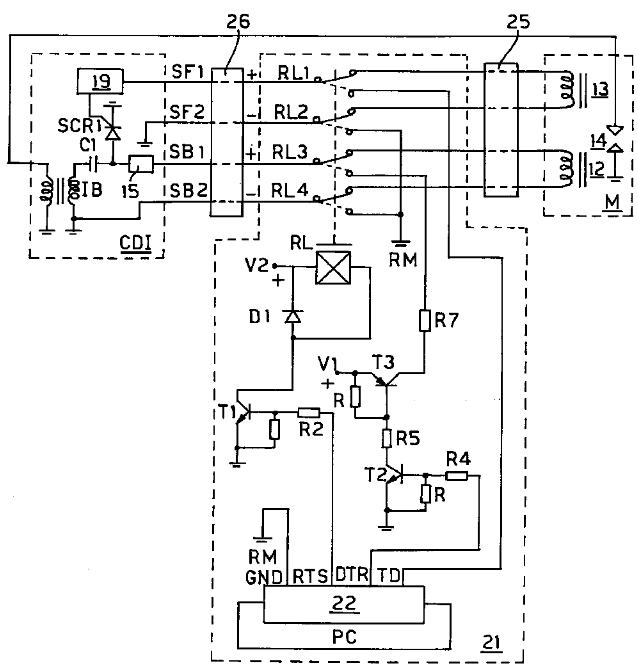

FIG. 3

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Description

The present invention relates to a method and an apparatus for setting the timing of the ignition systems of internal combustion engines and in particular relates to a method and an apparatus by means of which correction of the spark advance can be performed in an extremely simple and controlled manner both at the end of a production line and at any other time, eliminating moreover the risk of intentional tampering by non-authorised personnel.

In internal combustion engines in which a suitable ignition system is used, it is essential to have a correct timing of the ignition spark with respect to the thermodynamic cycle of the same engine.

An electric ignition of either the capacitive or inductive type for internal combustion engines, usually comprises an electric voltage generator having a feed coil for providing electric power to a storage circuit connected to the spark plugs of the engine. A timing sensor or pick-up is arranged in the generator in order to emit cyclically timing signals for synchronization with the thermodynamic cycle of the engine; the timing signals are supplied to a control unit inside the ignition circuit, which governs the entire ignition cycle, by activating and/or deactivating an electronic control switch at the time when the induction of a high voltage is required in the spark-plug feed circuit of the engine. Ignition circuits of this kind are widely known and described in numerous prior patents and an illustration thereof in the form of a block diagram is shown in Figure 2 of the accompanying drawings.

It is also known that, in internal combustion engines, it is generally necessary for the spark to be generated in advance of the top dead centre of the piston stroke so as to ensure optimum start-up and operative conditions for the engine.

Since the mechanical tolerances for machining and assembling of the various components of the engine as well as the tolerances of the timing pick-up and those of the electronic circuitry of the ignition system do not always allow the timing precision to be kept within the required tolerances, it is necessary to perform correct setting of the said ignition system when all the components involved are assembled at the end of an engine assembly line.

This setting operation is normally performed mechanically by adjusting a special eyelet arrangement which allows the position of the stator or the timing sensor to be changed according to requirement of the ignition system. However, the operations for mechanical adjustment of the timing sensor do not allow an high setting precision and require a considerable amount of time, thereby increasing the manufacturing costs of engine manufacturers.

In some cases the setting of the electronic components of an ignition system can be performed by means of suitable equipment; however, in this case the ignition system must be provided with special-purpose connections, which must be removed at the end of the assembly line after final setting of the timing, or with bridging connections which must be cut or with suitable potentiometers which must be adjusted.

All these solutions have considerable drawbacks: in particular, in the case where a simple binary coding system is used, the setting is performed with just a few advance intervals available and in general is not very precise; moreover, in the case of resin-embedded ignition units, the use of potentiometers or cables which need to be cut, or in any case the supplying of signals, involves industrial production problems which are often costly to solve. Finally, with these solutions in most cases it is not possible to suitably protect the ignition from having its setting altered by unauthorised personnel.

An object of the invention is to provide a method and an apparatus for setting the timing of ignition systems of internal combustion engines, by means of which it is possible to overcome the drawbacks mentioned above.

In particular one object of the present invention is to provide a method and an apparatus by means of which it is possible to perform an accurate setting of the ignition timing without having to perform any mechanical operations on the various components involved during assembly of the engine.

Another object of the present invention is to provide a method and an apparatus for setting the timing of ignition systems of internal combustion engines, as mentioned above, in which the setting is performed by connecting the ignition system to a suitable outer apparatus, using solely the connections necessary for normal operation of the same ignition system; in this way, the need to provide in the said ignition circuit, devices or connecting parts exclusively or mainly intended for the timing, is eliminated. In this way the ignition system as well as the assembling operations of the engine and timing process are simplified.

A further object of the present invention is to provide a method and an apparatus as defined above, in which the setting of the ignition is obtained in a non-volatile manner, lasting for the entire operating life of the same ignition.

Yet another object of the invention is to provide a method and an apparatus for setting the timing of the ignition of internal combustion engines, in which the setting operation is repeatable, allowing subsequent operations for modifying the same setting of the engine.

Finally, another object of the invention is to provide a method and an apparatus allowing a coded setting procedure accessible only to authorised personnel, thus avoiding any deliberate tampering.

These and other objects are obtained by means of a method and an apparatus for setting the timing of ignition systems of internal combustion engines having the characteristic features of the main claims 1 and 4. In general, according to the invention, the setting of the timing is performed by arranging a special setting unit in the wiring between the ignition circuit and the voltage generator of the engine and by effecting a setting cycle to allow a preliminary check as to the timing with the engine operating at a predetermined running speed, followed by setting the necessary correction of the timing performed with the engine at stopped conditions, and a subsequently checking that the correction of the timing performed is accurate.

In particular, the main feature of the invention consists in the fact that timing correction data are transmitted by the setting apparatus to a process unit of the ignition system, by means of a suitable coding system, via the same lines for effecting connection to the feed coil and to the timing pick-up of the voltage generator.

The method and a particular preferred embodiment of an apparatus for setting the timing according to the invention, will be described in greater detail hereinbelow, with reference to the accompanying drawings, in which:

Fig. 1 shows a conventional wiring diagram for connecting an engine and ignition system for normal operation;

Fig. 2 is a block diagram illustrating a capacitive-discharge ignition system suitable for setting the timing according to the invention;

Fig. 3 shows a general diagram of a setting apparatus arranged in an ignition circuit in accordance with the invention;

Fig. 4 is a diagram of the timing curves of a general internal combustion engine, before and after timing correction;

Fig. 5 is a graph showing timing of the ignition power supply and the timing signal during normal operation;

Fig. 6 is a graph showing the timing of the ignition power supply and the timing signal during a setting operation according to the invention;

Fig. 7 shows a flow diagram for management of the setting operation by the applicative program of the microprocessor inside the ignition system.

Figure 1 shows a conventional wiring diagram for connecting a capacitive discharge ignition system (CDI) to the electric voltage generator and the spark plugs of an engine. In particular, reference 10 denotes the magnetic rotor of a voltage generator which, in a manner known per se, is mechanically connected and rotated in synchronism with the movement of the piston 11 of the engine. In said figure, reference 12 schematically indicates the feed coil supplying the electric power for ignition, while 13 schematically indicates the timing sensor or pick-up which sends a succession of timed signals to the CDI system to control the time when the spark is produced in the spark plugs 14 of the engine M.

More particularly, as shown in the block diagram of Figure 2, the CDI system, in the case of a capacitive-type ignition, comprises a charging circuit 15 for charging the capacitor C1 by the current generated by the feed coil 12, while reference 16 denotes the circuit supplying the voltages necessary for the charging circuit 15. The capacitor C1 is in turn provided in a discharge circuit comprising the primary winding 17 of an ignition coil IB, as well a controlled electronic switch consisting, for example, of the SCR 1. The secondary winding 18 of the ignition coil IB is in turn connected to the spark plugs 14 of the engine.

The CDI system comprises moreover a microprocessor 19 provided with a non-volatile and programmable memory of the EEPROM type, the output of which is connected to the control electrode of the electronic switch SCR1 for triggering discharging of the capacitor C1.

The microprocessor 19 in turn receives at its inlet side timing signals from the pick-up 13 via a conditioning and filtering circuit 20.

As explained below, the microprocessor 19 is programmed to manage the process for triggering the spark each time a pulse is received from the pick-up 13; moreover its EEPROM memory comprises an applicative program which allows self-memorising of the timing correction on the basis of data received from a setting unit 21 described below and shown in the following Figure 3.

In Figure 3, the setting unit, denoted in its entirety by 21, is detachably connected in series, by connectors 25, 26 between the ignition CDI and the voltage generator 12, 13 of the engine M, as indicated by the respective blocks in which the symbols of the components necessary for describing operation thereof have been shown.

Said setting unit 21 substantially comprises a relay or switching device RL having switch-over contacts RL1, RL2, RL3 and RL4 connected to the lines SF1, SF2, SB1 and SB2 which normally connect the pick-up 13 to the microprocessor 19 inside the CDI system, as well as the ignition coil 12 to the charging circuit 15 of the capacitor C1.

More particularly, the contacts RL1, RL2, RL3, RL4 of the relay are able to switch between the position shown in continuous lines in Figure 3, where they connect coils 12, 13 of the voltage generator of the engine M directly to the CDI unit, and the position shown in broken lines in the same figure, where they connect the CDI unit to the setting unit 21.

More precisely, the contact RL1 is switchable into the position shown in broken lines where it connects the line SF1 for the positive of the timing signal directly to an output TD of a serial port 22 of a computer PC provided with a control keyboard, which is programmed with a suitable applicative program; in place of the personal computer PC a specially dedicated digital control unit may be used.

The second contact RL2 is provided in the line SF2 of the negative timing signal and can switch into the position shown in broken lines where it connects the line SF2 to a reference earth RM of the said setting unit.

Correspondingly, the contact RL3 is disposed in the line SB1 of the positive signal of the feed coil and is able to switch into the position shown in broken lines where it connects the inlet side of the microprocessor 19 of the CDI unit to a positive supply voltage via a resistor R7 and an electronic switch T3 controlled by the signal at the outlet DTR of the serial port 22. In the example shown, the electronic switch T3 consists of a transistor of the PNP type, the base of which can be polarized to earth via a resistor R5 and the collector-emitter circuit of a second transistor T2, the base of which is in turn connected to the outlet DTR of the serial port 22 via the resistor R4. However, it is obvious that, in place of the transistor, it would be possible to use any other electronic switch controlled by the signals output from DTR.

Finally, the fourth contact RL4 of the relay RL is provided in the line SB2 associated with the reference earth of the feed coil and can be switched into the position shown in broken lines for connection again to the earth RM of the setting unit 21.

Correspondingly, the coil of the relay RL can he connected to a supply voltage source V2 via a third transistor T1, the base of which can be polarized, via the resistor R2, by a signal at the outlet RTS of the serial port 22, while GND denotes a fourth outlet of the serial port 22 connected to the earth RM of the setting unit.

Operation of the apparatus and the method for setting the timing of the ignition system according to the present invention will be described hereinbelow, again with reference to the diagram of Figure 3 and the subsequent figures of the accompanying drawings.

Let us assume that the timing curve A1 of Figure 4 must be corrected by a certain number of degrees in order to bring it into the position A2 shown in broken lines in the same figure. The personal computer PC or, where present, the digital logic of the setting unit 21 has the function of managing the signals RTS, DTR and TD at the respective outputs in order carry out the setting cycle in the manner illustrated hereinbelow: when the signal RTS is low, the transistor T1 is inhibited, so that the relay RL is not powered and its contacts RL1 to RL4 are in the position shown in continuous lines in Figure 3. In this condition the electronic CDI unit will be connected directly to the timing sensor or pick-up 13 and to the feed coil 12, as shown. In this condition the engine M may be normally started up and it will be possible to detect, by means of suitable instrumentation, any timing errors and hence the amount of correction to be performed which will be entered in the EEPROM memory of the PC by means of its control keyboard.

When the personal computer PC, via its applicative program stored in its non-volatile programmable memory causes the signal RTS to go high, T1 will be made to conduct. The relay RL will therefore be powered changing its contacts RL1 to RL4 from the position shown in continuous lines to that shown in broken lines in Figure 3. In this condition, the contacts RL2 and RL4 will connect the line SF2 as well as the line SB2 with the earth RM of the setting unit 21. At the same time, the line SF1 of the positive timing signal will be connected, via the contact RL1 of the relay, directly to the outlet TD of the serial port of the personal computer, while the line SB1 of the positive signal of the feed coil 12 will be connected, via the resistor R7, to the transistor T3. Since the outlet DTR of the PC is initially at a low state, the transistor T2 will be inhibited, thereby preventing conduction of the transistor T3. In these conditions, the CDI unit is not energised by V1; instead, when the applicative program of the personal computer causes the signal at the outlet DTR to go high, the transistor T2 will start to conduct, causing the transistor T3 to conduct as well, thus allowing the CDI unit to be energised at the time T1, as shown in Figure 6.

At this point, after a predetermined waiting time DT2 calculated from T1 at which the energising of the CDI is started by the setting unit 21, long enough to allow the microprocessor 19 of the electronic CDI unit to recognise the signals coming from the setting unit, discriminating them from those coming from the pick-up 13 during normal working, the setting unit 21, still in accordance with the operative program of the personal computer, will send via the outlet TD a serial transmission S3 of data relating to the value of the desired timing correction, preceded by an access code S2. After completing correction of the timing, the signals DTR and RTS will be made to go low again, thus interrupting the supply to the CDI unit and the relay RL which will bring its contacts RL1, RL2, RL3 and RL4 into the initial condition shown in continuous lines in Figure 3; in this condition, the setting unit will allow the accuracy of the correction made to be verified. The setting cycle is thus completed and, at this point, the setting unit can be removed, allowing the CDI unit to be directly and permanently connected to the respective engine.

As previously mentioned, recognition of the various situations relating to normal operation or the setting operation of the electronic CDI unit is based on the timing of the pulses of the timing signals with respect to the time T1 when the CDI is powered. The applicative program stored in the non-volatile programmable memory of the microprocessor 19, which manages the electronic CDI unit, also manages the timing signals and self-memorising of the corrected timing curve, recognising whether the pulses supplied to the said microprocessor can be associated with normal operation and hence running of the engine, or with a codified transmission of new setting data.

All this can be understood more clearly with reference to the graphs in Figures 5 and 6 as well as the flow diagram of Figure 7.

In Figure 5, B1 is the graph, over time, of the voltage supply to the CDI which, after T1, remains constant, while B2 is the graph for the timing signals supplied by the pick-up 13 under normal ignition operating conditions. In these conditions, it is assumed that the first pulse S1 of the timing signal starts at the time T2, with a delay DT1, for example of the order of 300 msec. or less, when the engine is operating at a predetermined running speed.

B3 in Figure 6, on the other hand, illustrates the voltage supply of the CDI, again calculated from the instant T1, while B4 is the graph of the code S2 which allows access to the memory of the microprocessor 19 of the CDI, and of the signal S3 relating to the amount of the timing correction to be performed.

Still with reference to Figure 6, T3 denotes the time instant when the microprocessor 19 of the CDI reads the access code of the output DT of the personal computer of the setting unit, with a delay DT2 corresponding to a predetermined waiting time, for example of five seconds, considerably greater than the delay DTI of 300 msec. of the first timing signal S1 during normal operation of the ignition circuit, referred to above.

In particular, the applicative program of the CDI is such that if the first pulse on the timing line SF1 is received from the microprocessor 19 within a period of time less than the waiting time DT2 entered in the applicative program of the setting unit, necessary for emission of the access code S2, this pulse and the successive ones will be interpreted as pulses S1 supplied from the pick-up 13 which therefore will be managed by the microprocessor 19 to achieve normal operation of the ignition unit.

On the other hand, if the first pulse S3 on the line SF1 is received and recognised by the microprocessor 19 of the ignition system after the access code S2, when said predetermined time period DT2 has already lapsed, this pulse and the successive ones will be interpreted as being associated with transmission of the timing correction data by the setting unit 21, and the applicative program of the microprocessor 19 of the ignition system will perform decoding thereof and self-programming of the decoded data in the non-volatile memory (EEPROM) present in the said microprocessor.

The possibility of the microprocessor 19 of the ignition unit to assume that the pulses which arrive after a predetermined period of time, from the start T1 of powering thereof, are supplied from the setting unit 21, is due to the fact that, during normal operation of the ignition connected to the engine, energisation of the circuit is guaranteed only if the motor is running; therefore, the pulses of the pick-up 13 are necessarily associated with the energised condition.

Therefore, the waiting time DT2 must be sufficiently long, in general much greater than the period occurring between two consecutive timing signals at the predetermined running speed of the engine.

As already mentioned, in order to avoid the risk of possible accidental or incorrect programming, prior to the correction to be programmed in the microprocessor 19 of the CDI unit, a predetermined access code S2 is initially transmitted during which accidental programming of the microprocessor 19 becomes practically impossible, even in the case of temporary disconnection or false contacts on the line SF1 of the timing pick-up.

Figure 7 of the accompanying drawings shows by way of example the flow chart for management of the setting cycle, contained in the applicative program of the electronic CDI unit. After initialization (step 30), from the instant T=O, counting is started by the timer inside the microprocessor (step 31). During counting, if the microprocessor 19 receives a timing signal in a predetermined period of time, the microprocessor program checks whether this time is greater than the predetermined waiting interval DT2 indicated above. If the reply is negative, i.e. if the pulse is received prior to the waiting time DT2, after verifying whether there has been any variation in level of the said signal received (step 33), the microprocessor 19 manages the timing signals S1 so as to activate normal ignition advance during normal operation of the engine (step 34).

On the other hand, if the first pulse on the timing pick-up line is recognised after the predetermined period DT2, from step 32 one passes to step 35 involving reading of the access code and if the system answers affirmatively (step 36) one passes to step 37 involving reading of the value corresponding to the correction to be made to the timing signal, as well as writing of the corresponding correction value in the EEPROM memory (step 38). The operative system of the microprocessor 19 automatically memorises in this way the new correct timing curve, with return again to step 34 involving management of the signal for activation of the ignition advance.

From the above description and illustrations in the accompanying drawings it is therefore obvious that a method and an apparatus for setting the timing of the ignition systems of internal combustion engines have been provided, by means of which it is possible to obtain a non-volatile setting which is able to last for the entire working life of the ignition, said setting being made reversible, i.e. also providing the possibility of modifying the setting subsequently, while retaining a high degree of security owing to a coded procedure which makes the entire system accessible only to authorised personnel. Therefore, in addition to protection against tampering, owing to the fact that operations can be carried out directly via the lines of the feed coil and the timing sensor, significant simplification and reduction of the operating times, and in any case extremely precise setting of the timing, are made possible.

Claims

1. Method for setting the timing for the spark advance of the ignition circuit (CDI) of an internal combustion engine (M), in which said ignition circuit (CDI) comprises an electric power storage circuit (C1) inductively connected to the spark plug circuit (14) of the engine (M), respectively connected to the feed coil

(12) of a voltage magneto-generator (10,12) having a rotor (10) mechanically linked to the rotating shaft of the piston (11) of the engine, and in which said voltage generator comprises a timing pick-up coil (13) to cyclically emit timing signals supplied to a microprocessor (19) of the ignition circuit (CDI), said microprocessor (19) being provided with a non-volatile programmable memory for activating and/or deactivating an electronic control switch (SCR1) in the said electric power storage circuit (C1), characterized by:
providing an electronic time setting unit (21) having a power source (V2) for setting the spark advance of said ignition circuit (CDI), said time setting unit (21) comprising a control unit (PC) having programmable memory means comprising a coded setting procedure for providing time setting signals to the microprocessor (19) of the ignition circuit (CDI), said time setting unit (21) being detachably connectable between the feed coil (12) and the timing pick-up coil (13) of the voltage generator, and said ignition circuit (CDI);
checking the timing for the spark advance of the ignition circuit (CDI), while keeping the engine (M) running at a predeterminate speed, and determining the amount of advance correction to be performed for timing the spark advance of said ignition circuit (CDI);
disconnecting said voltage generator from said ignition circuit (CDI), and supplying the microprocessor (19) of the ignition circuit (CDI) with a set of timing signals (S3) corresponding to the correction to be performed for the spark-advance of the engine, directly through the same wire connections of the ignition circuit (CDI) to the feed coil (12) and the pick-up coil (13) of the voltage generator, after lapsing a predetermined time delay from the start of the powering of said ignition circuit (CDI).

2. Method for setting the timing for the spark advance of the ignition circuit of an internal combustion engine according to Claim 1, characterized by sending an authorisation code allowing the access to the microprocessor (19) of the ignition circuit (CDI), before sending to said microprocessor (19) the signals provided by said time setting unit (21) for correcting the spark advance.

3. Method for setting the timing for the spark advance of the ignition circuit of an internal combustion engine according to Claim 1 or 2, characterized in that said microprocessor (19) of the ignition circuit (CDI) is provided with operative program means designed to recognise the timing signals provided by the pick-up coil (13) of the voltage generator (12, 13) during the running of the engine, in respect to a coded transmission of advance correction data, in accordance with a different timing compared to the start of the powering of the ignition circuit (CDI).

4. Apparatus suitable for setting the timing for the spark advance of the ignition circuit of internal combustion engines, according to the method of previous claims, characterized by comprising: switch contact means (RL1 ÷ RL4) which can be programmably actuated to directly connect said ignition circuit to the feed coil (12) and the timing pick-up coil (13) of the voltage generator of the engine (M), respectively connect said setting apparatus to the ignition circuit (CDI) via the same wire connection for the feed coil (12) and the timing pick-up coil (13) of the said ignition circuit (CDI); control means (RL, T1, T2, T3) being provided for actuating said switching contacts (RL1 ÷ RL4) respectively, for connecting said ignition circuit (CDI) to a voltage source (V2) and to a reference earth (RM) inside the said apparatus; and a control unit (PC) provided with a programmable non-volatile memory comprising operative program means to activate the ignition circuit (CDI) and to generate, with a predetermined time delay, a succession of coded signals indicative of the spark advance correction to be performed to said ignition circuit.

5. Apparatus according to Claim 4, characterized in that said non-volatile memory means of the control unit (PC) is programmed to send access code data for accessing the microprocessor (19) of the engine ignition circuit (CDI), before generating said succession of coded signals indicative of the spark advance correction for said ignition circuit (CDI).

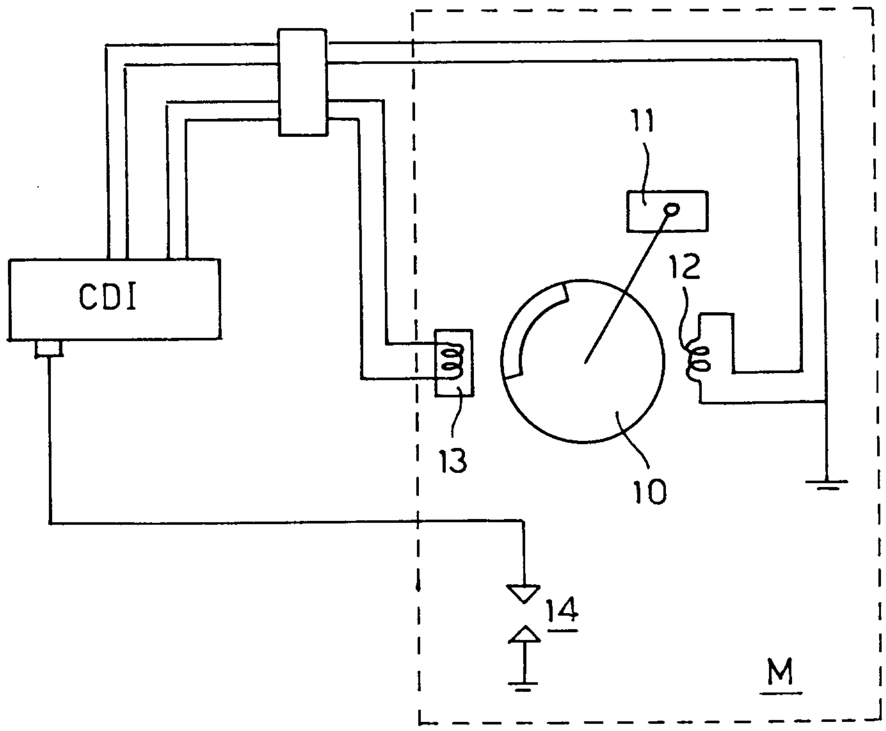


FIG. 1

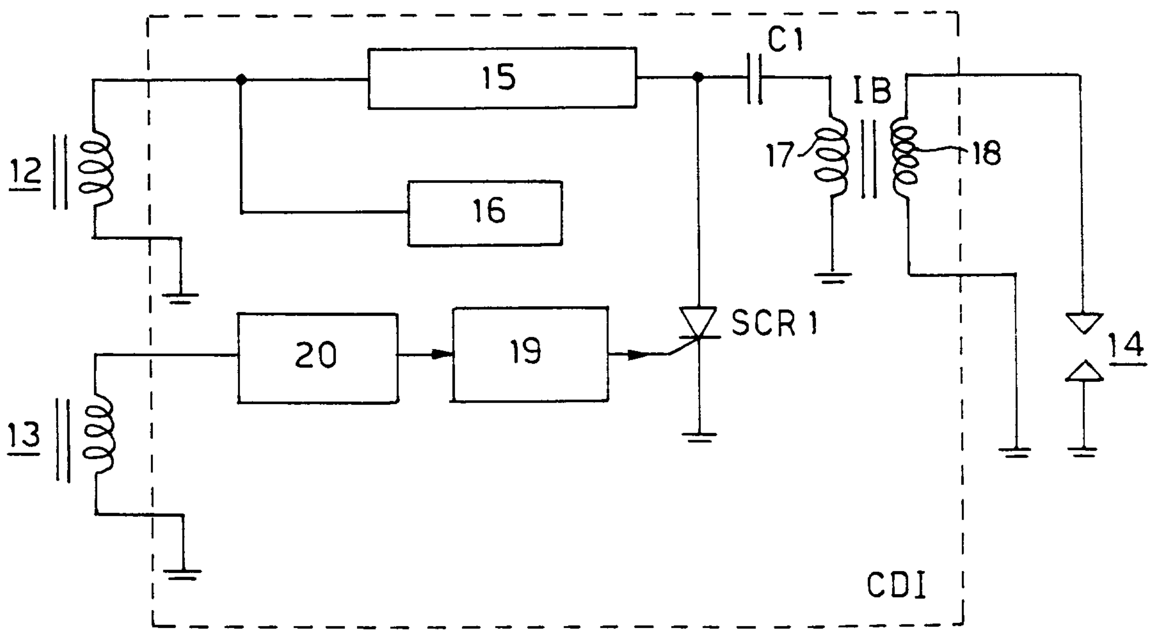


FIG. 2

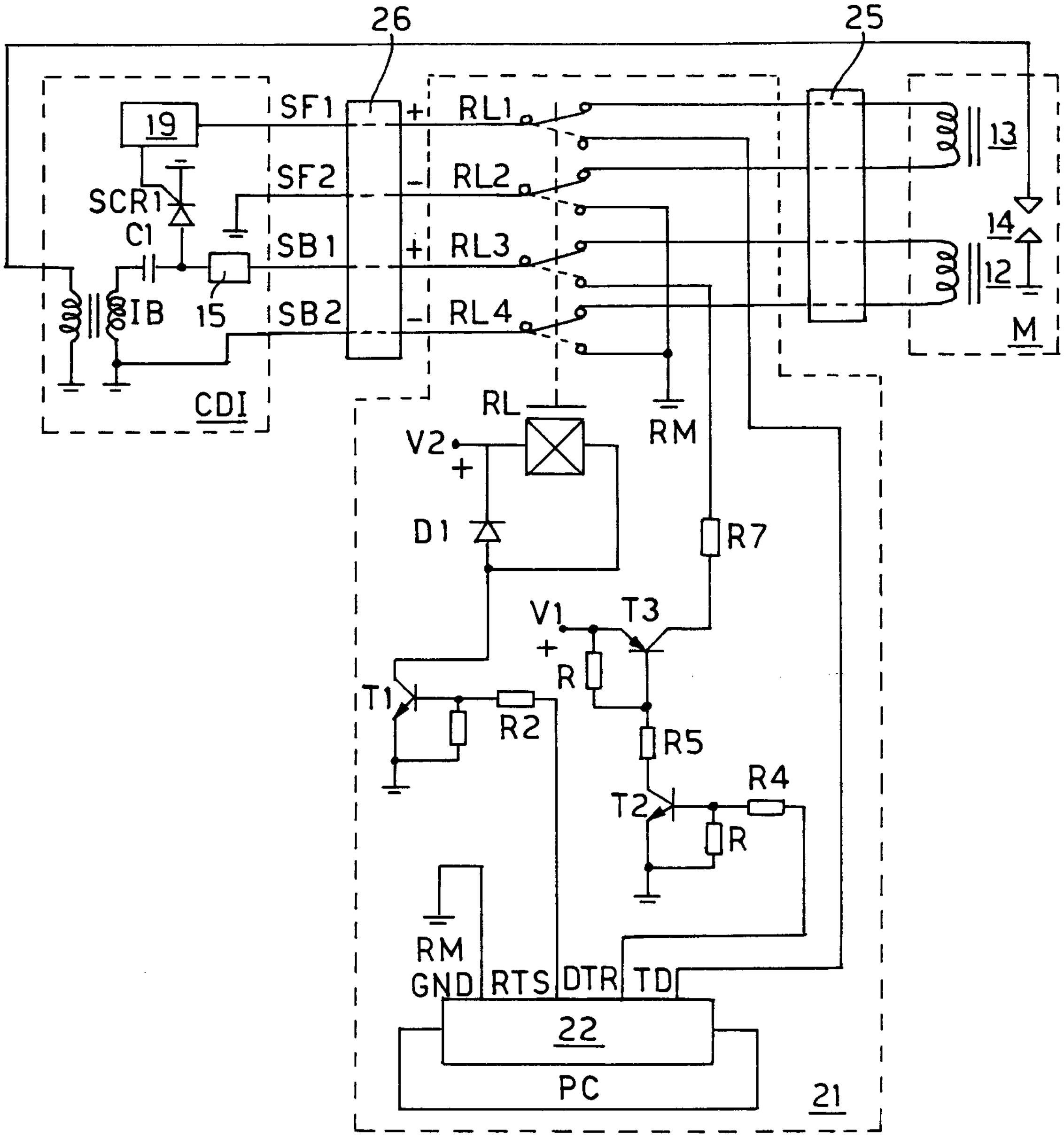

26
25
19
SF1
SF2
SB1
SB2
SCR1
C1
IB
15
CDI
RL1
RL2
RL3
RL4
RL
RM
V2
D1
R7
V1
T3
R
R5
T1
R2
T2
R4
R
RM
GND
RTS
DTR
TD
22
PC
21
13
14
12
M

FIG. 3

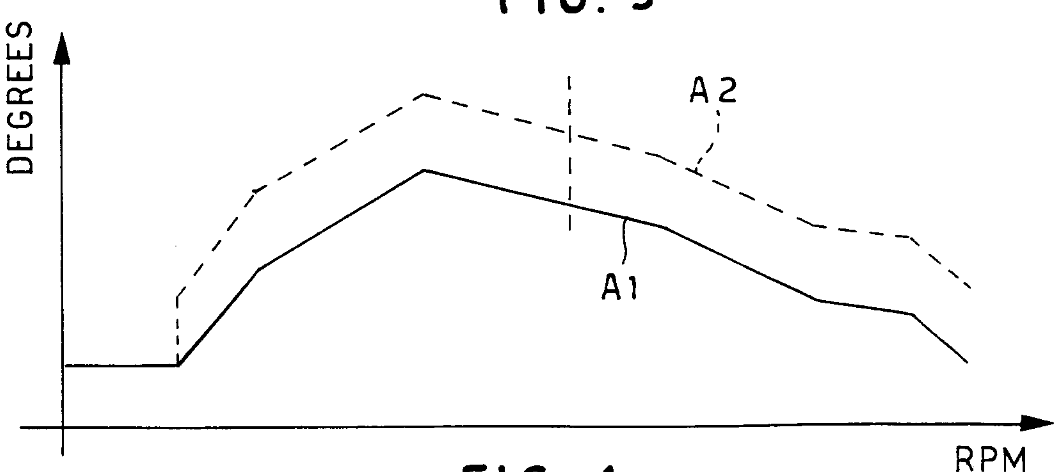

DEGREES
A2
A1
RPM

FIG. 4

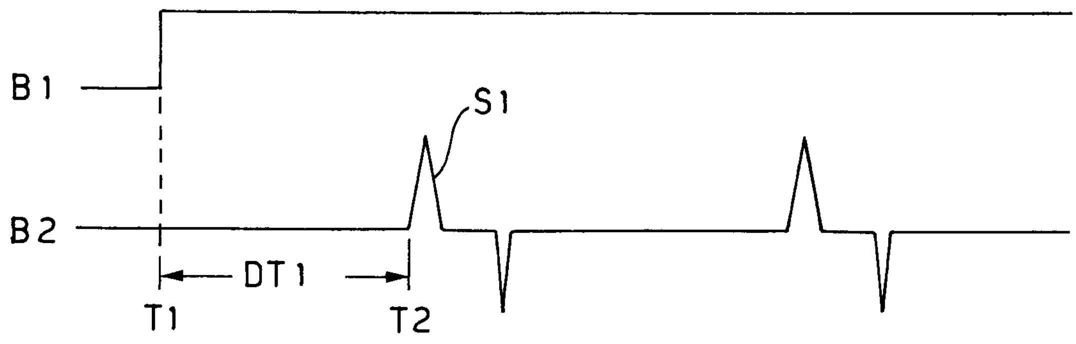


FIG. 5

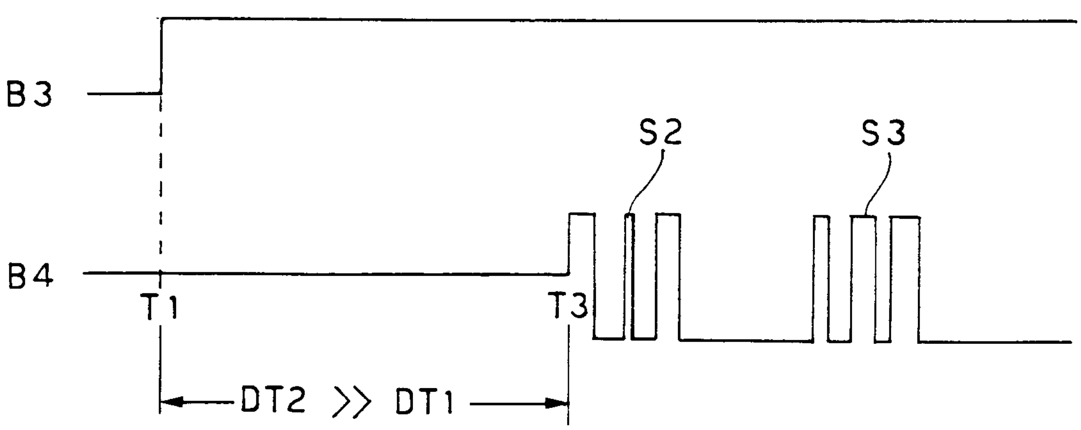
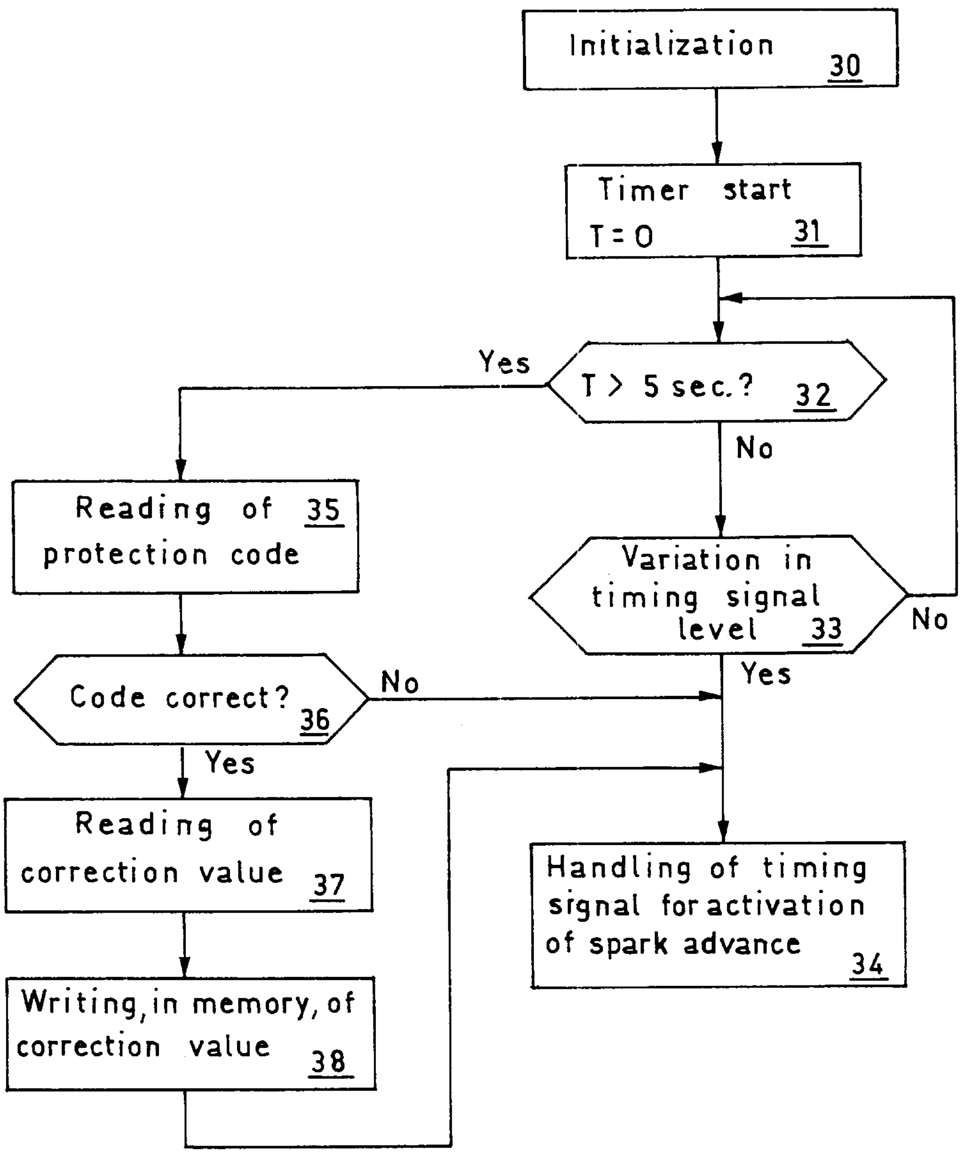


FIG. 6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Timer start
T=0 31
T > 5 sec.? 32
Yes
No
Reading of protection code 35
Variation in timing signal level 33
No
Yes
Code correct? 36
No
Yes
Reading of correction value 37
Handling of timing signal for activation of spark advance 34
Writing, in memory, of correction value 38

FIG. 7