

[54] TRANSISTORIZED IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

[75] Inventor: **Richard Beuter**, Plettenberg, Germany

[73] Assignee: **Brown, Boveri and Cie A.G.**, Mannheim, Germany

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Primary Examiner—Manuel A. Antonakas

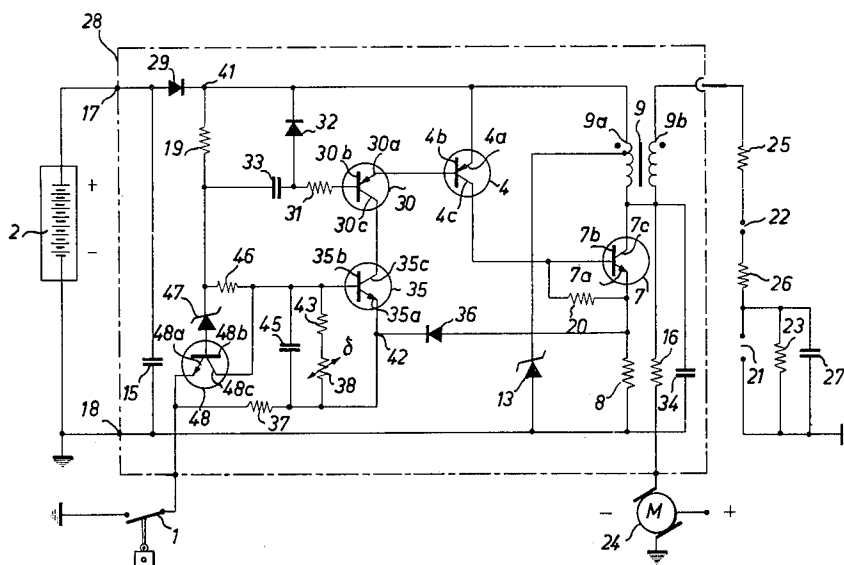
Assistant Examiner—Joseph A. Cangelosi

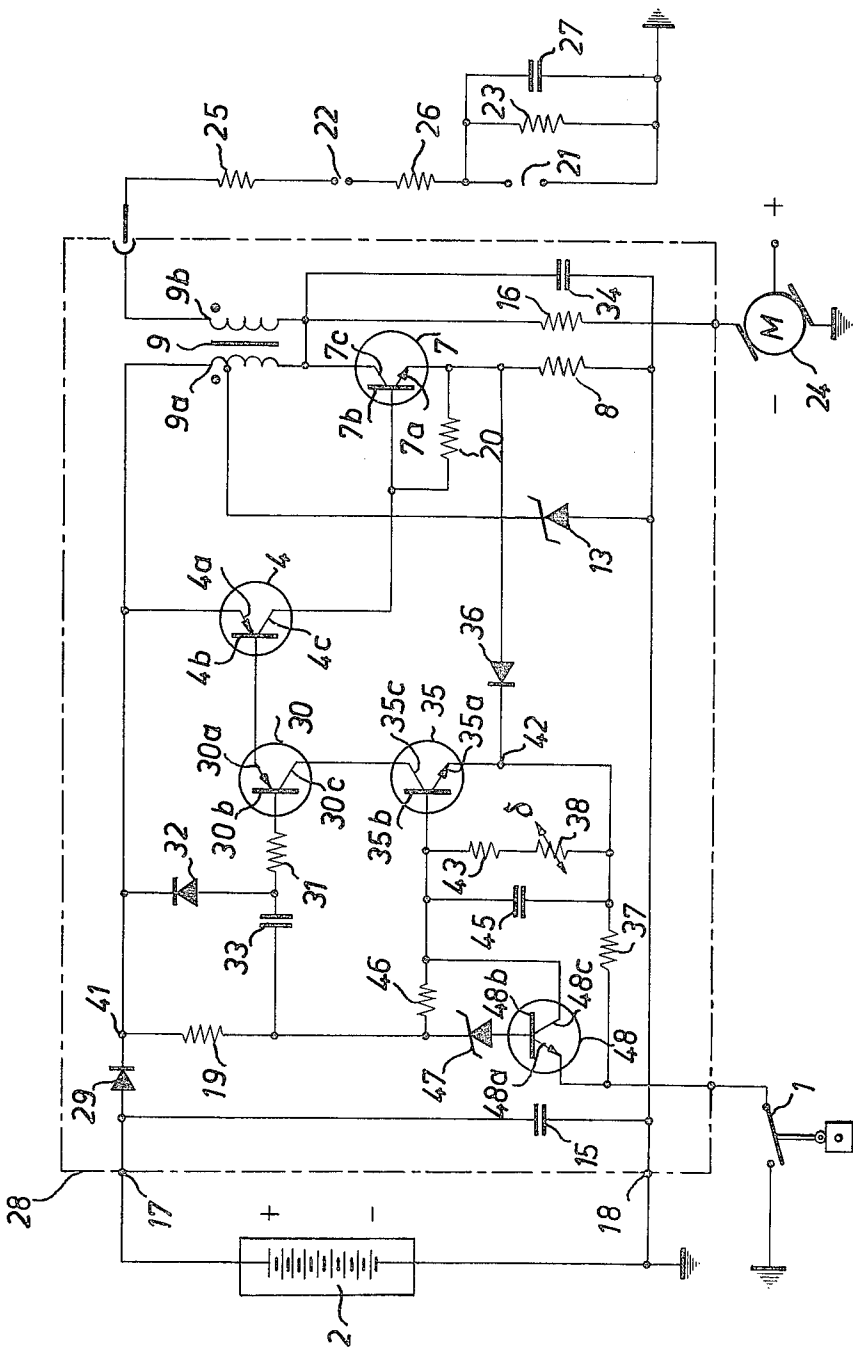
Attorney, Agent, or Firm—Erwin Salzer

[57] ABSTRACT

An ignition system for internal combustion engines is provided with means for (1) reducing to virtually zero variations of the primary energizing current of the ignition coil, or obtaining the highest charging current though the terminal voltage of the d-c current supply undergoes variations; (2) interrupting the flow of the ignition coil energizing current automatically upon a predetermined time following cessation of the operation of the internal combustion engine, and (3) preventing connection of transistors to terminals having the wrong polarity, and thus causing destruction of improperly connected diodes or transistors.

4 Claims, 1 Drawing Figure





TRANSISTORIZED IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This application relates to an improvement of the ignition system disclosed in the copending patent application **IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES** filed 01/09/74; Ser. No. 431,832 of Heinrich-Josef Brungsberg, commonly assigned.

This invention relates to ignition systems for internal combustion engines including a source of d-c current, an interrupter, an ignition coil and semiconductor means including resistor means. In such systems the charging current stores energy in the primary winding of the ignition coil, and the secondary winding of the ignition coil generates a voltage which is sufficiently high for the purpose of ignition.

The above referred-to patent application of Heinrich-Josef Brungsberg discloses means for maintaining the flow of current in the primary winding of the ignition coil substantially constant over the entire range of numbers of revolutions of the internal combustion engines, even if the d-c voltage of the supply battery should decline. These means include a main control transistor which is arranged in series with the primary winding of the ignition coil and with a negative feed-back resistor. The collector of this transistor is connected to one end of the primary winding of the coil, and the emitter of this transistor is connected to one end of the aforementioned negative feed-back resistor. The circuitry further includes a control transistor. The collector of the latter is connected to the base of the aforementioned main control transistor which is a power transistor, and the emitter of the latter is connected to the positive terminal of a battery or d-c power supply.

The system disclosed in the above patent application is capable of stabilizing the charging current of the ignition coil only to a certain extent. This extent is determined by the extent to which the characteristic curves of components vary, tolerances of the components of the circuitry vary, and the amplification of amplifying components vary. If the voltage of the d-c power supply varies between $\pm 30\%$, the current may vary in the order of $\pm 10\%$.

The principal objects of the present invention are to reduce variations of the charging current intensity to virtually zero, or to achieve the highest charging currents and consequently the highest ignition voltages though but the smallest d-c voltages are available, and further to interrupt the current flow after a predetermined period of time when the internal combustion engine is not operating and finally to prevent improper connection of semiconductor elements into the circuit, i.e., applying a voltage of the wrong polarity to semiconductor elements, which might result in the destruction thereof.

The invention includes the addition of certain parts to the basic circuitry disclosed in the above referred-to patent application. These parts effect a better stabilization of the loading current and regulate the nominal or desired voltage level.

SUMMARY OF THE INVENTION

The circuitry embodying the present invention includes in addition to the main power transistor and its auxiliary control transistor forming part of the system

disclosed in the above patent application, a pre-transistor, a second auxiliary control transistor, and a regulating transistor. The collector of said regulating transistor is connected to the base of said second auxiliary control transistor, the collector of said second auxiliary control transistor is connected to the collector of said pre-transistor, the emitter of said second auxiliary control transistor is connected first by means of a resistor to one of the contacts of the interrupter of the ignition system and also to the emitter of said regulating transistor and secondly to the cathode of a diode whose anode is connected to the emitter of said main power transistor as well as to a negative feed-back resistor. The end of said negative feed-back resistor remote from said anode of said diode is connected to the negative terminal of a d-c power supply. The collector of said regulating transistor is connected to the base thereof by the intermediary of a resistor and a Zener diode. The base of said second auxiliary control transistor is connected, on the one hand, by means of resistors to the positive terminal of a d-c power supply and, on the other hand, by means of a first resistor, an additional temperature sensitive resistor, a damping capacitor, and another resistor to both the emitter of said regulating transistor and one of the contacts of the interrupter of the system.

The above circuitry is a means for automatic enhancement of low temperature motor starting. The temperature-sensitive resistor has a negative resistance coefficient of temperature which is a particular means that enhances low temperature motor starting.

The above circuitry and some of its additions described below effect after a certain time delay following cessation of the operation of the internal combustion engine opening of energizing circuitry of the system, though the contacts of the interrupter remain in engagement.

BRIEF DESCRIPTION OF THE DRAWING

The drawing is a circuit diagram of a system embodying the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

In the drawing reference numeral 1 has been applied to indicate an interrupter having relatively movable contacts, and reference numeral 2 has been applied to indicate a battery. Battery 2 includes a positive terminal (above) and a negative terminal (below). Reference numeral 9 has been applied to indicate an ignition coil including the primary or low voltage winding 9a and the secondary or high voltage winding 9b. The main transistor 7 is a power transistor which controls the current flow through the primary winding 9a. The primary winding 9a of ignition coil 19 is arranged in series with the collector-emitter circuit 7a, 7c of main transistor 7, and also in series with negative feed-back resistor 8. The latter is connected with the end thereof remote from transistor 7 to the negative terminal of battery 2. Reference numeral 4 has been applied to indicate a first auxiliary control transistor for driving transistor 7. The collector 4c of transistor 4 is connected to the base of transistor 7 and the emitter 4a of transistor 4 is connected to the positive terminal of power supply 2. Reference numeral 30 has been applied to indicate a pre-transistor, reference numeral 35 has been applied to indicate a second auxiliary control transistor, i.e., one in addition to first transistor 4, and

reference numeral 48 has been applied to indicate a regulating transistor. The collector 48c of regulating transistor 48 is connected to the base 35b of transistor 35. The collector 35c of transistor 35 is connected to the collector 30c of pre-transistor 30. The emitter 35a of transistor 35 is connected by the intermediary of resistor 37 to one contact of interrupter 1 as well as to emitter 48a of regulating transistor 48b. The emitter 35a of transistor 35 is connected to the cathode of diode 36, and the anode of diode 36 is connected to a point intermediate emitter 7a of transistor 7 and negative feed-back resistor 8. The collector 48c of transistor 48 is connected by the intermediary of resistor 46 and Zener diode 47 to the base 48b of transistor 48. Base 35b of transistor 35 is connected by the intermediary of the aforementioned resistor 46, an additional resistor 19, and diode 29, to the positive terminal of battery 2. A network including resistor 43 and temperature sensitive resistor 38, a damping capacitor 45 and a resistor 37 interconnects the base 35b of transistor 35 and the emitter 48a of transistor 48 and one contact of interrupter 1.

The circuitry which has been described above in general terms differs from the circuitry disclosed in the above referred to patent application mainly by the addition to the former of another amplifier stage in the control circuit of the charging current, and by the addition of a regulator for regulating the nominal voltage. The control of the nominal voltage is mainly effected by transistor 48, Zener diode 47 and resistor 46.

If interrupter 1 is in the contact closed position a current path is established which includes the positive terminal of battery 2, potentiometer resistor 19, Zener diode 47 and the base 48b and the emitter 48a of transistor 48. Hence transistor 48 is turned on, and its collector 48c assumes a certain potential. This potential is the set value, or set point, or nominal value. It is applied to the base 35b of transistor 35. The transistor 35 remains fully turned on as long as the actual voltage at the feed-back resistor 8 is less than the set value, or set point. When the actual voltage and the set value or set point are substantially equal, the charging current has a predetermined value.

The above considerations apply to a stable or fixed voltage of battery 2.

Assuming now that the voltage of battery 2 increases, this results in an increase of the current in the circuit of regulating transistor 48 across its base 48b and its emitter 48a. Hence the potential of its collector 48c is reduced. This, in turn, results in a reduction of the set value or set point prevailing at the base 35b of transistor 35 and, in turn, a reduction of the charging current. This makes it possible to keep the charging current absolutely constant, or even to reduce the charging current, even if the voltage of the d-c power supply should increase as much as 100%.

The circuitry described above allows starting enhancement under low temperature conditions (d-c voltage 8 volt, maximum current; d-c voltage 16 volt, minimum current). The increase in the ignition energy when the motor is started is achieved by the combination of several means. The set value or set point of the voltage and the actual value thereof are coupled by means of a series arrangement of resistor 43 and temperature sensitive resistor 38 which extends parallel to the basis - emitter current path 35b, 35a of transistor 35. When an internal combustion engine is started at a

relatively low temperature, the ohmic value of resistor 38 is relatively high. Hence there is virtually no current flow in the current path formed by serially arranged resistors 43 and 38. No current flow means no equalization of the potential across resistors 43, 38 and, therefore, the set point or set value for control transistor 35 remains high. As the temperature of the internal combustion engines increases, the resistance of resistor 38 decreases and the potential of the base 35b of transistor 35 decreases likewise which, in turn, results in a decrease of the charging current of ignition coil 9. It has been found that if the temperature changes from -40°C to $+100^{\circ}\text{C}$, the charging current changes but in the order of 20%.

The problem of interrupting the charging current within a short time, e.g., 2-3 seconds, when the internal combustion engine is not operating and when the interrupter contacts are closed, is solved in the following fashion by means of the pre-transistor 30, the resistor 31 connected to the base 30b of transistor 30, the capacitor 33 and the discharge diode 32. The emitter 30a of the pre-transistor 30 is connected to the base 4b of transistor 4, and the collector 30c of transistor 30 is connected to the collector 35c of transistor 35. The base 30b of transistor 30 is connected by the intermediary of resistor 31 and capacitor 33 to a point intermediate resistor 19 and the cathode of Zener diode 47. The point intermediate resistor 31 and capacitor 33 is connected to the anode of diode 32, whose cathode is connected to the plus terminal of battery 2.

Current interruption at standstill of the internal combustion engine is effected as follows:

At the time when the contacts of the interrupters 1 are closed or in engagement, capacitor 33 is entirely discharged. A sufficient base current flows into the pre-transistor 30 which charges capacitor 33 and causes pre-transistor 30 to be fully turned on. As the capacitor 33 is charged gradually, the base current of pre-transistor 33 decreases and becomes finally zero. Thus pre-transistor 30 blocks, and the primary current of the ignition coil 9 becomes likewise zero. Since this process involves time, no high voltage is induced in the secondary winding 9b of ignition coil 9. When the contacts of interrupter 1 part, capacitor 33 is discharged in a short time by way of diode 32.

The time constants are selected in such a way that at starting rpms of 60 there is no effect on the charging current of the capacitor.

It is well known that if the proper polarity of diodes and of transistors is not observed, the same may be damaged, and that this occurs quite frequently during maintenance and repair operations. In order to avoid such damage, the diode 29 is interposed between the positive pole of the battery 2 and the rest of the circuitry. Diode or rectifier 29 is arranged in such a way that its anode is connected to the positive pole of the battery 2, and its cathode is connected to the junction point 41 of resistor 19, to the cathode of diode 32, to the emitter 4a of transistor 4, and to one end of the primary winding 9a of ignition coil 9. Thus diode 29 provides permanent protection against inversion of polarity of the semiconductor elements of the circuitry.

The line including the resistor 16 has one end interconnecting collector 7c of transistor 7 and primary winding 9a and another end which is connected to revolution counter 24. The coupling resistor 20 is arranged in parallel to the current path from base 7b to

emitter 7a of transistor 7. The series arrangement of power transistor 7 and negative feed-back resistor 8 is shunted by a protective capacitor 34 for transistor 7.

A dash-and-dot line 28 is intended to indicate a housing for the constituent parts of the circuitry. The housing 28 is provided to the left side thereof with a pair of terminals 17 and 18.

The high voltage circuit of secondary winding 9b of the ignition coil includes resistors 25 and 26, spark plug 22, and distributor 21. Reference numeral 23 has been applied to indicate a shunt resistor, and reference numeral 27 has been applied to indicate the capacitance of the line.

I claim as my invention:

1. An ignition system energized by a d-c power source for internal combustion engines including
 - a. an ignition coil (9) having a primary winding (9a) and a secondary winding (9b);
 - b. an interrupter (1) for interrupting the current flow in said ignition coil (9);
 - c. a main transistor (7) controlling the current flow in said primary winding (9a) of said ignition coil (9), said primary winding (9a) of said ignition coil (9) being arranged in series with the collector-emitter circuit (7a, 7c) of said main transistor (7) and in series with a negative feed-back resistor (8) connected to the negative terminal of a d-c power supply;
 - d. a first auxiliary control transistor (4) having a collector (4c) connected to the base (4b) of said main control transistor and an emitter (4a) connected to a d-c power supply;
 - e. a pre-transistor (30), a second auxiliary control transistor (35) and a regulating transistor (48), the collector (48c) of said regulating transistor (48) being connected to the base (35b) of said second auxiliary control transistor (35), the collector (35c) of said second auxiliary control transistor (35) being connected to collector (30c) of said pre-transistor, the emitter (35a) of said second auxiliary control transistor (35) being connected by the intermediary of a resistor (37) to one contact of said interrupter (1) and to the emitter (48a) of said regulating transistor (48), the emitter (35a) of said secondary auxiliary control transistor (35) being further connected by the intermediary of a diode (36) to the emitter (7a) of said main

transistor (7) and to said negative feed-back resistor (8), the cathode of said diode being arranged adjacent the emitter (35a) of said second auxiliary control transistor (35) and the anode of said diode (36) being arranged adjacent the emitter (7a) of said main transistor (7), said collector (48c) of said regulating transistor being further connected to the base (48b) thereof by the intermediary of a resistor (46) and a Zener diode (47), said base (35b) of said second auxiliary control transistor (35) being connected to the positive terminal of a d-C power supply by the intermediary of resistor means (46, 19) and

f. a network including a resistor (43), a temperature sensitive resistor (38), a damping capacitor (45) and additional resistor means (37) interconnecting said base (35b) of said second auxiliary control transistor (35) with the emitter (48a) of said regulating transistor (48) and with one contact of said interrupter (1).

2. A system as specified in claim 1 wherein said resistor (43) and said temperature sensitive resistor (38) are arranged in series in said network and have such parameters that the sum of the ohmic resistance thereof remains substantially constant over a wide range of temperatures.

3. A system as specified in claim 1 having means for automatically de-energizing said primary winding (9a) of said ignition coil (9) upon interruption of operation of an internal combustion engine, said de-energizing means including a series arrangement of resistors (19, 31) and of a capacitor (33) arranged in the current path from the positive terminal of a d-c power supply (2) to the base (30b) of said transistor (30) to turn off said pre-transistor when said capacitor is fully charged, and a diode (32) allowing said capacitor (30b) to be discharged upon opening of the contacts of said interrupter (1).

4. A system as specified in claim 3 wherein a diode (29) is arranged between said positive terminal of said power supply (2) and said series arrangement of resistors (19, 31) and of a capacitor (33), said emitter (4a) of said first auxiliary transistor (4) and one end of said primary winding (9a) of said ignition coil (9) to preclude damage to said system when applying voltages of inverse polarity to the terminals (17, 18) thereof.

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