United States Patent [19]

Canup

[11] **3,861,369**

[45] **Jan. 21, 1975**

[54] **IGNITION-CONTROL SYSTEM FOR INTERNAL COMBUSTION ENGINES**

[75] Inventor: **Robert E. Canup,** Richmond, Va.

[73] Assignee: **Texaco, Inc.,** New York, N.Y.

[22] Filed: **June 19, 1972**

[21] Appl. No.: **263,803**

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

[56] **References Cited**

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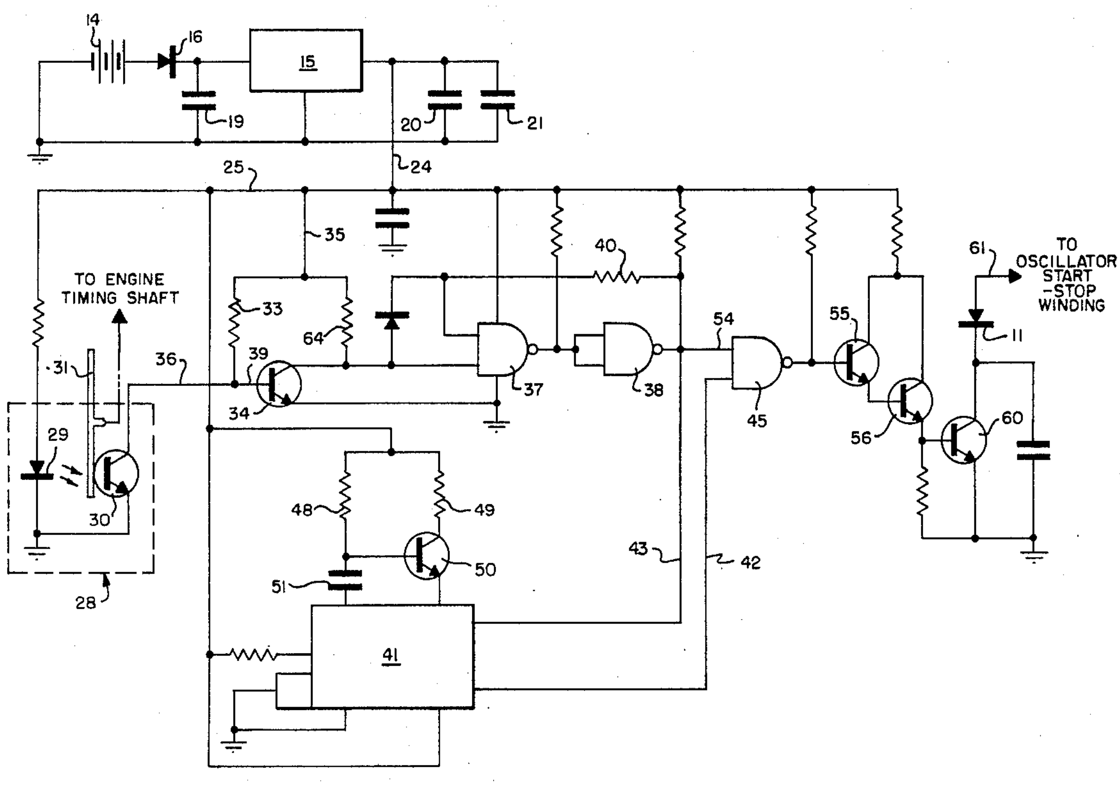
Assistant Examiner—Ronald B. Cox
Attorney, Agent, or Firm—T. H. Whaley; C. G. Ries

[57] **ABSTRACT**

An ignition system for internal combustion engines. It has an oscillator to produce continuous-wave high-frequency spark energy, and includes a control winding for starting and stopping the oscillator during controlled engine-timed intervals. There is electronic time-delay control for stopping the oscillator if the engine stalls with the oscillator running. The system may also include a relay controlled by the ignition switch. And one purpose of the latter is to shut down the oscillator whenever the ignition switch is turned off during a spark event.

4 Claims, 3 Drawing Figures



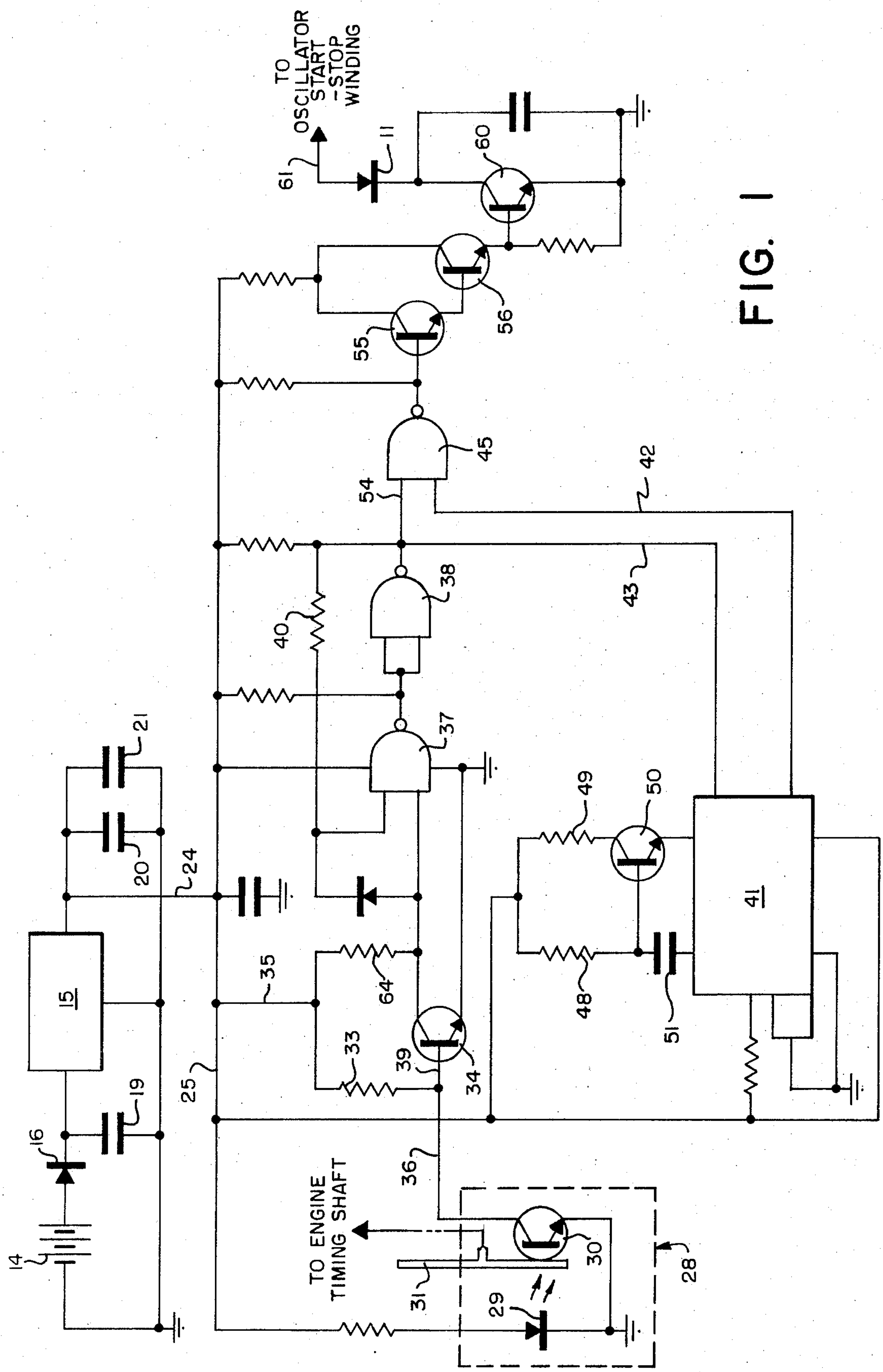

TO OSCILLATOR START -STOP WINDING
61
11
60
56
55
45
54
42
38
43
40
37
21
20
24
49
50
41
15
35
64
48
51
33
39
34
25
19
16
36
14
TO ENGINE TIMING SHAFT
30
31
29
28

FIG. 1

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3 Sheets-Sheet 2

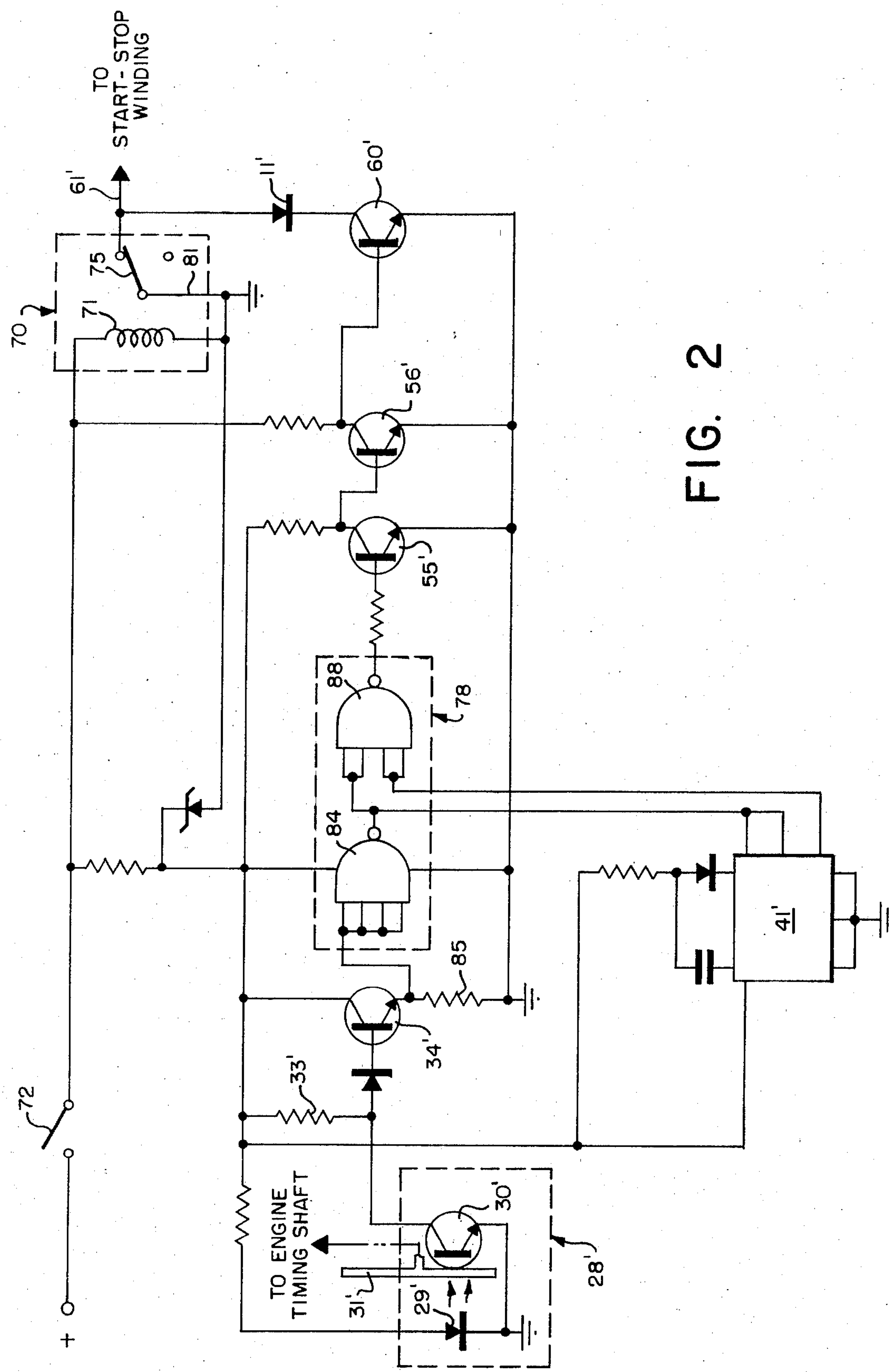

FIG. 2

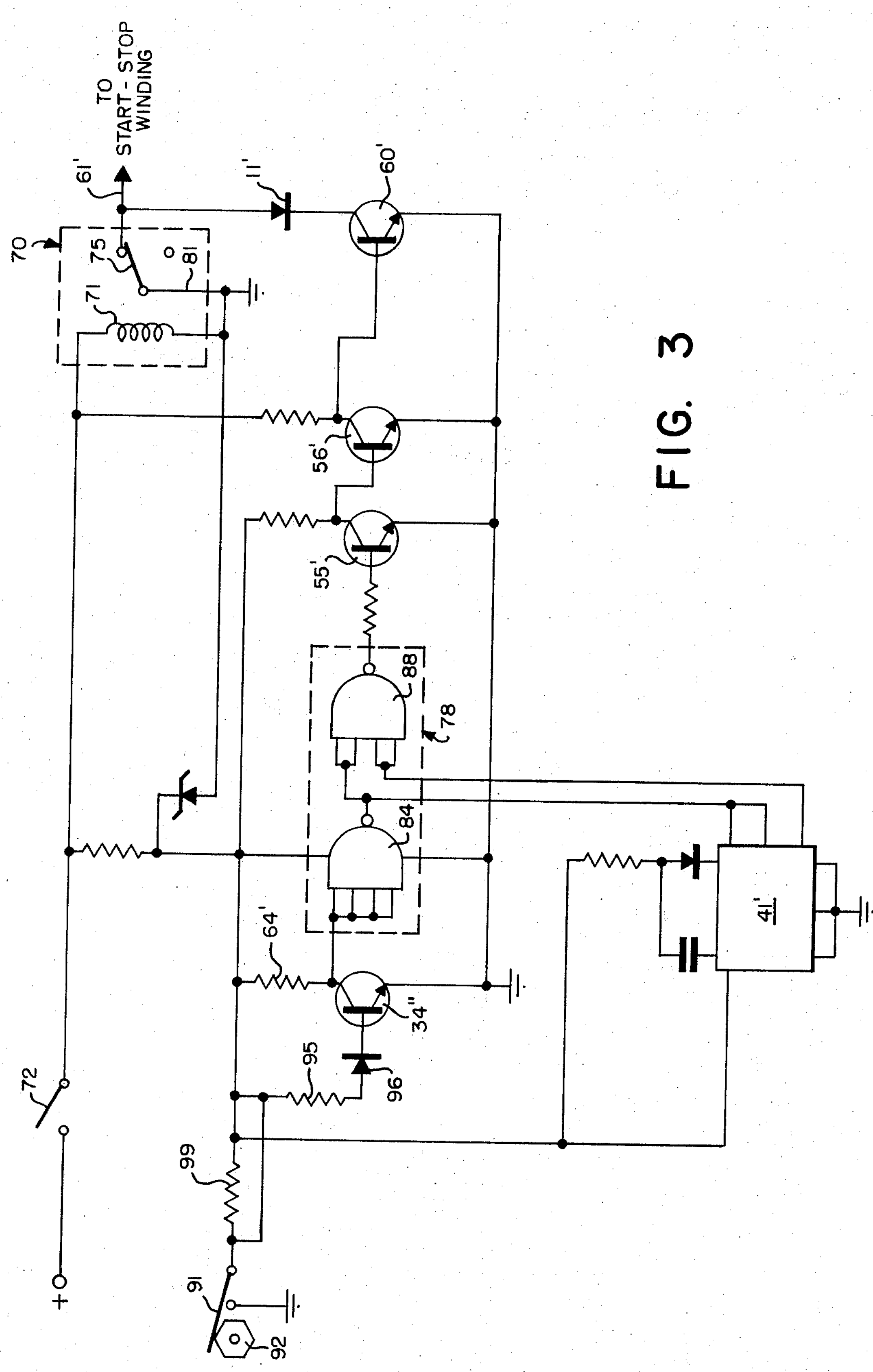
TO START-STOP WINDING
61'
11'
60'
70
75
81
71
56'
55'
88
78
84
64'
34''
95
96
72
99
91
92
41'
+

FIG. 3

IGNITION-CONTROL SYSTEM FOR INTERNAL COMBUSTION ENGINES

CROSS REFERENCES TO RELATED APPLICATIONS

This application is related to my copending applications Ser. No. 193,909, filed Oct. 29, 1971 now U.S. Pat. No. 3,792,645; Ser. No. 209,060, filed Dec. 17, 1971; and Ser. No. 232,094, filed Mar. 6, 1972 now U.S. Pat. No. 3,779,226.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention concerns ignition systems for internal combustion engines, in general. More specifically, it relates to an improved ignition system for controlling continuous-wave high-frequency spark energy.

2. Description of the Prior Art

While there are numerous suggestions with a multitude of variations, all concerning different ignition systems for internal combustion engines, these have for the most part not been found acceptable for one reason or another. Most conventional ignition-system arrangements are concerned with a single-spark discharge for igniting the charge in each cylinder of the engine, and it may be created in different ways, e.g., by so-called capacitor discharge or by other arrangements that provide a single-surge type of high-voltage output signal. In all such arrangements, there is developed only a single short-duration electrical spark at each spark plug and, consequently, the ignition may not take place with maximum efficiency.

Consequently, it is an object of this invention to provide an improved ignition-control system that is applicable to the type of ignition circuit which employs a controlled-duration continuous-wave high-frequency spark signal.

SUMMARY OF THE INVENTION

Briefly, this invention relates to an ignition system for an internal combustion engine wherein said system employs controlled-duration continuous-wave high-frequency spark energy. The said spark energy is generated by an oscillator that has a control winding for starting and stopping oscillation thereof at the beginning and end of each spark interval. In relation to such system, the invention concerns a combination that comprises electronic switching means for instantaneous opening and closing of a loading circuit for said control winding at the beginning and end of each spark interval. It also comprises engine-timed means for actuating said switching means in predetermined relation to said engine operation.

Again, briefly, the invention concerns an ignition system for an internal combustion engine wherein the system employs controlled-duration continuous-wave high-frequency spark energy. The said spark energy is generated by an oscillator having a control winding for starting and stopping oscillation thereof at the beginning and end of each spark interval. It comprises in combination a transistor and engine-timed means for actuating said transistor in predetermined relation to said engine operation. The engine-timed means comprises an infrared-light-emitting diode, a photo transistor and a shutter driven by said engine. The combination also comprises circuit means for connecting said engine-timed means to said transistor including a regenerative trigger. Said circuit means comprises a first amplifier between said photo transistor and said regenerative trigger, and a second amplifier between said regenerative trigger and said transistor. The combination also comprises time-delay means for reactuating said transistor after a predetermined interval if said shutter has stopped leaving said photo transistor energized by said light-emitting diode. Said time-delay means comprises a retriggerable monostable multivibrator, and said circuit means also comprises a NAND gate having at least two inputs one from said multivibrator and one from said trigger. Said circuit means also comprises a circuit connection from said trigger to an input of said multivibrator. The combination also comprises a relay, an ignition switch, and additional circuit means for connecting said relay to said control winding for stopping said oscillator whenever said ignition switch is turned off.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objects and benefits of the invention will be more fully set forth below in connection with the best mode contemplated by the inventor of carrying out the invention, and in connection with which there are illustrations provided in the drawings wherein:

FIG. 1 is a schematic circuit diagram illustrating one preferred modification according to the invention;

FIG. 2 is a schematic circuit diagram illustrating a similar system as FIG. 1 but with some additional elements supplied and some elements omitted; and

FIG. 3 is another schematic circuit diagram illustrating an adaption of the FIG. 2 circuit in order to employ conventional breaker points with the system.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

It is to be noted that all of the systems of this invention are particularly applicable to controlling the generation of spark signals by a continuous-wave high-frequency oscillator. Such oscillator (not shown) must include a control winding which determines the commencement and termination of such spark signal.

A control winding according to the foregoing is indicated in FIG. 1 by the caption "TO OSCILLATOR START-STOP WINDING." It will be appreciated by reference to the above-noted copending applications that such a spark-signal-generating oscillator with its control winding may take various forms. Such oscillators include the feature of having a control for starting and stopping the oscillator by breaking and making an electrical connection from one end of the control winding to ground, e.g., the end indicated which is in series with a diode **11** shown in FIG. **1**. The other end (not shown) is unidirectionally grounded through one of parallel paths that include a diode for half-wave grounding of AC current and a source of DC to create a magnetic bias in the transformer core of the oscillator. The "making" consequently acts to load down the oscillator on a predetermined half cycle and, thus, stops the oscillation with the magnitization in a predetermined desired direction.

In other words, it may be noted that the loading circuit includes a diode, e.g., the diode (not shown) which carries reference number 86 in my above noted application Ser. No. 193,909 (D No. 72,528). Such diode acts so that the last half-cycle of current flow of the oscillator loading AC current in the control winding will be in a predetermined direction. Consequently, it will insure the proper oscillator starting characteristics for the next spark oscillations. This aspect has been also shown and explained in one, or more, of my other applications.

The control system shown in FIG. 1 may make use of solid-state electronic circuit elements so that the arrangement becomes highly reliable and does not need much space. In the FIG. 1 illustration, there is no ignition switch illustrated, but it is to be understood that one would be provided in an appropriate location in the system. There is shown a battery **14** that may be a conventional 12-volt of 24-volt automobile-type battery. The voltage supplied to the system might range from as low as 7½ to as high as 30 volts, and in order to provide for a stable system, there is employed between the positive terminal of the battery **14** and the B+ voltage supply to the system, a voltage regulator **15.** It is connected to the + side of the battery **14** via a diode **16** which is preferably included so as to guard against reversal of the battery terminals. Voltage regulator **15** may be any feasible type, but it is preferably an integrated circuit like that manufactured by National Semiconductor Corporation of Santa Clara, Calif., which is designated by the manufacturer's number LM 309.

In order to smooth out any noise on the supply-voltage lead, there is a capacitor **19** connected across the input side of the regulator **15.** While, on the output side of the regulator **15,** there are two capacitors **20** and **21,** as illustrated. The latter two capacitors are included in order to assist the regulator **15** to overcome switching transients in the ignition-control system. The output of the regulated voltage side of the regulator **15** is connected via a circuit wire **24** to a B+ circuit connector **25** of the ignition-control system.

In the illustrated system, engine-timing of each spark signal is determined by using a sensing unit **28** located in the automobile distributor (not shown), and which includes an infrared-emitting diode **29** that has its output focused on the base junction of a photo transistor **30.** There is also a rotating shutter **31** that is mechanically driven from the engine crank shaft (as indicated by the caption) so that the timing of a predetermined number of openings or slits in the shutter will be positioned in front of the transistor **30** only when a spark signal is required. At all other positions of the shutter the radiation from the diode **29** is prevented from reaching the photo transistor **30.**

When the light, i.e., infrared energy from diode **29** is permitted to reach the photo transistor **30,** the transistor becomes conducting and, therefore, draws current through a resistor **33.** Resistor **33** is connected between the B+ circuit connection **25** and the collector electrode of transistor **30** by means of circuit connections **35** and **36.** Such current flow causes a voltage drop, and the consequent reduction of voltage at the collector of transistor **30** is also applied to the base electrode of a transistor **34** via a connection **39.** This reduced voltage causes transistor **34** to stop conducting. When that happens, the voltage at the collector electrode of transistor **34** will rise toward the B+ voltage, i.e., that provided at the output of voltage regulator **15.**

There are two solid-state integrated circuit elements **37** and **38** that are each made up of a two-input positive NAND gate which has an open collector output. These are connected into a Schmitt trigger configuration which includes a feedback resistor **40** connected between the output from element **38** to one input of the other element **37.** These elements **37** and **38** may be two parts of a quadruple element integrated circuit unit, as manufactured by Texas Instruments Incorporated of Dallas, Tex., and sold under the designation of SN 7401.

When the input to the first element **37** of the Schmitt trigger reaches a certain level, the Schmitt trigger changes state extremely rapidly, and the output of the gate element **38** goes from a relatively low-voltage to a relatively high-voltage level in a few nanoseconds. Then the positive-going edge of such signal created by the Schmitt trigger, is applied to an input, via a connector **43,** to a retriggerable monostable multivibrator unit **41.** This multivibrator unit **41** may be one such as that commercially available as an integrated circuit manufactured by Texas Instruments Incorporated and designated SN 74122.

The output of unit **41** will go to a high level and be carried via a circuit connection **42** to the input of a NAND gate **45.** The multivibrator unit **41,** when triggered, will remain in that state for a predetermined period of time. Such time is determined by the time constant of a network that includes a resistor **48,** another resistor **49,** a transistor **50,** and a capacitor **51.** The multivibrator unit **41** acts such that its time constant is renewed, i.e., it it reset each time additional triggering pulses are received. However, if no such retriggering pulses are applied to the input connection **43,** the multivibrator will toggle itself to the original state at the end of the predetermined time period.

There is a circuit connection **54** from the output of the second element **38** of the Schmitt trigger to one input of the NAND gate **45.** The circuit connection **42** from the output of the unit **41** is applied to the other input of the NAND gate **45.** Therefore, the output of gate **45** will go to its low-voltage state and, thus, turn off a Darlington-connected pair of transistors **55** and **56.** Consequently, the driving current to a transistor **60** is removed, and its current flow is cut off.

Transistor **60** acts to cut off the flow of the DC bias current (indicated above) in a start-stop (or control) winding indicated. And, the control winding is connected via a circuit connection **61,** the diode **11** and the transistor **60** to ground, as illustrated.

When the current flow in the control winding is cut off, the oscillator (not shown) is instantaneously started and a continuous-wave spark signal is generated until the shutter **31** of unit **28** cuts off the infrared-light path between diode **29** and the photo transistor **30.** That will end the spark-signal oscillations because base current will be permitted to flow once more into the transistor **34.** Consequently, transistor **34** will draw collector current through a resistor **64,** and such current flow will reduce the voltage at the input to the first element **37** of the Schmitt trigger thus causing it to change state and making the output shift to a low voltage. The low voltage is applied to one input of NAND gate **45** (over connection **54**) and will cause its output to go high which, in turn, will drive the transistors **55, 56,** and **60** into conduction. When transistor **60** conducts, a sufficient load is placed on the oscillator (not shown) via the circuit connection **61** to stop the oscillation. Also, the DC magnetic bias current that may then flow through transistor **60,** will set the core of the magnetic circuit of the oscillator so as to place it in the proper magnetic state for instant starting the next time that the transistor **60** ceases to conduct.

In case the engine should stall with the shutter **31** of unit **28** in a position that permits radiation from diode **29** to reach transistor **30**, the output from the Schmitt trigger would remain high. However, after the predetermined time interval, which is determined by the time constant of the one-shot multivibrator **41** (as indicated above), the multivibrator would reset itself so that its output is zero. That condition would be applied to the other input of NAND gate **45** via connection **42** and would cause its output to go high, which would turn off the oscillator, as previously explained.

It will be noted that by making use of the voltage regulator **15**, a system according to the invention may be applied without change to 12- or 24-volt-battery systems.

Also, it will be noted that the control of the continuous-wave sparking signal intervals is directly related to degrees of crank shaft angle and is not affected by the rate at which the crank shaft is turning. On extremely slow cranking speeds the voltage at the collector of transistor **34** will rise slowly. However, when the voltage reaches a predetermined level, the regenerating action of the Schmitt trigger will cause it to toggle and change states. Consequently, the system is operable down to zero rpm cranking speed.

Another function of the multivibrator **41** comes into play under very slow cranking speeds. If the spark should fail to start the engine and the opening in the shutter **31** should remain in front of the transistor **30**, the multivibrator would reset itself and again the oscillator would be turned off, thus reducing unnecessary drain on the battery.

Referring to FIG. **2**, it will be noted that the same basic system is employed as that described above in connection with FIG. **1**. The same elements are designated with the corresponding reference numbers but with a prime mark added. However, in addition to the similar elements employed, this system shows the feature of adding a relay unit **70** that has a coil **71** which is connected via an ignition switch **72** to the B+ voltage supply.

A switch element **75** of the relay **70** is biased to the illustrated position when the coil **71** is not energized. Consequently, whenever the ignition switch is turned on, i.e., switch **72** is closed, the winding **71** of relay **70** will be energized and switch arm **75** will be opened so that an auxiliary short-circuiting connection **81**, from the start-stop winding connection **61'** to ground, will be removed.

The purpose of the foregoing arrangement is to enable the oscillator unit (not shown) to have its power-supply connection (not shown) permanently connected to the B+ voltage supply. This will avoid a lengthy heavy-duty circuit wire running from the battery all the way to the ignition switch and back to the vicinity of the distributor. This is so since the oscillator unit, along with a control unit according to this invention, will be located adjacent to the distributor structure on an internal combustion engine. The same concept but without the use of a relay, is disclosed in my copending application Ser. No. 232,094 mentioned above. However, in that arrangement the ignition switch had an extra set of contacts.

Otherwise, the system illustrated in FIG. **2** is substantially like that of FIG. **1**, and the details of its operation need not be described. It will be noted that there is a unit **28'** substantially like unit **28** of FIG. **1** and, similarly, there is a Schmitt trigger unit **78** which replaces the integrated circuit elements **37** and **38** as well as the NAND gate **45** of FIG. **1** Thus, there is one Schmitt trigger element **84** that has all four of its inputs connected in common to the output from the transistor **34'**. The transistor **34'** has its output connected via the emitter circuit, with a resistor **85** therein, instead of via the collector circuit with resistor **64**, as in FIG. **1**.

A second Schmitt trigger element **88** is connected as a two-input NAND gate so as to act similarly as the NAND gate **45** of FIG. **1**. Thus, the output of element **84** goes both to one input of the NAND gate **88** and to the corresponding input of the retriggerable monostable multivibrator unit **41'** vis-a-vis the FIG. **1** unit **41**. The other input of the NAND gate **88** is connected to the output from unit **41'** so as to receive the enabling signal so long as unit **41'** has been triggered, or retriggered.

Transistors **55'** and **56'** correspond to the pair of transistors **55** and **56** in FIG. **1**, but in FIG. **2** they (**55'** and **56'**) are connected in a straight amplifier configuration, instead of as a Darlington-connected pair.

FIG. **3** illustrates the same control system as in FIG. **2**, but adapted to employ engine-timed breaker points, instead of an optical sensing unit as in FIGS. **1** and **2**. Thus, in FIG. **3**, there is shown a breaker-point switch **91** that is actuated by an engine-timed cam **92**.

In this modification, there is a transistor **34''** that is connected at its output in the manner that transistor **34** (FIG. **1**) was connected, i.e., there is a resistor **64'** in the collector circuit. It is the current flow through resistor **64'** that reduces the voltage at the input to Schmitt trigger element **84**.

It will be noted that initiation of a spark signal is created by the opening of breaker switch **91** because it makes the transistor **34''** conduct by raising the voltage applied to the base via a resistor **95** and a diode **96**. The voltage increase is caused by cutting off the current flow through a resistor **99** that exists whenever the switch **91** is closed.

It may be noted that in FIGS. **2** and **3** the Schmitt trigger unit **78** might be an integrated circuit package such as one manufactured by Texas Instruments Incorporated and designated SN 7413 N.

While the foregoing has described certain modifications of the invention in considerable detail in accordance with the applicable statutes, this is not to be taken as in any way limiting the invention but rather as being descriptive thereof.

I claim:

1. In an ignition system for an internal combustion engine, wherein said system employs controlled-duration continuous-wave high-frequency spark energy,

said spark energy being generated by an oscillator having a control winding for starting and stopping oscillation thereof at the beginning and end of each spark interval, the combination comprising

a transistor connected in series with said control winding for making and breaking a loading circuit which includes said control winding,

said transistor having a control circuit therefor,

engine-timed means associated with said control winding for determining said spark intervals,
said engine-timed means comprising
an infrared-light-emitting diode,
a phototransistor, and
a shutter driven by said engine,
circuit means for connecting said engine-timed means to said transistor control circuit,
said circuit means comprising a regenerative trigger,
time-delay means comprising a retriggerable monostable multivibrator for actuating said control circuit after a predetermined interval if said engine-timed means has stopped between said beginning and end of a spark interval,
said circuit means also comprising a first amplifier between said engine-timed means and said regenerative trigger,
a NAND gate having at least two inputs, one from said multivibrator and one from said trigger, and
a second amplifier between said regenerative trigger and said transistor.

2. The invention according to claim **1**, wherein said combination also comprises
an ignition switch for controlling energization of said ignition system,
a relay having a relay-control winding thereon in circuit with said ignition switch, and
switch contacts on said relay being connected in an auxiliary loading circuit for stopping oscillation of said oscillator whenever said ignition switch is turned off,
said auxiliary loading circuit being in parallel with said first-named loading circuit.

3. In an ignition system for an internal combustion engine wherein said system employs controlled-duration continuous-wave high-frequency spark energy,
said spark energy being generated by an oscillator having a control winding for starting and stopping oscillation thereof at the beginning and end of each spark interval, the combination comprising
electronic switching means for instantaneously opening and closing a loading circuit for said control winding at the beginning and end of each spark interval, said switch means comprising
a first transistor for controlling said loading circuit,
a Schmitt trigger for controlling said first transistor,
a retriggerable monostable multivibrator having an input and an ouput,
a NAND gate having an output connected to said first transistor and one input connected to the output from said multivibrator and another input connected to said Schmitt trigger,
a second transistor for applying an input signal to said Schmitt trigger,
engine-timed means for applying an input signal to said second transistor for switching said Schmitt trigger at the beginning and returning it at the end of each said spark interval, and said combination also comprising
an ignition switch for controlling energization of said ignition system,
a relay having a relay-control winding thereon in circuit with said ignition switch, and
switch contacts on said relay being connected in an auxiliary loading circuit for stopping oscillation of said oscillator whenever said ignition switch is turned off,
said auxiliary loading circuit being in parallel with said first named loading circuit.

4. In an ignition system for an internal combustion engine, wherein said system employs controlled-duration continuous-wave high-frequency spark energy,
said spark energy being generated by an oscillator having a control winding for starting and stopping oscillation thereof at the beginning and end of each spark interval, the combination comprising
electronic switcing means for instantaneously opening and closing a loading circuit for said control winding at the beginning and end of each spark interval,
engine-timed means for actuating said switching means in predetermined relationship to said engine operation,
an ignition switch for controlling energization of said ignition system,
a relay having a relay-control winding thereon in circuit with said ignition switch, and
switch contacts on said relay being connected in an auxiliary loading circuit for stopping oscillation of said oscillator whenever said ignition switch is turned off,
said auxiliary loading circuit being in parallel with said first-named loading circuit.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,861,369

DATED : January 21, 1975

INVENTOR(S) : Robert E. Canup

It is certified that error appears in the above–identified patent and that said Letters Patent are hereby corrected as shown below:

In the drawings, FIG. 3, remove a circuit connection from the upper end of resistor 95 to the circuit line extending from the right-hand end of resistor 99.

Signed and Sealed this

thirteenth **Day of** *January 1976*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

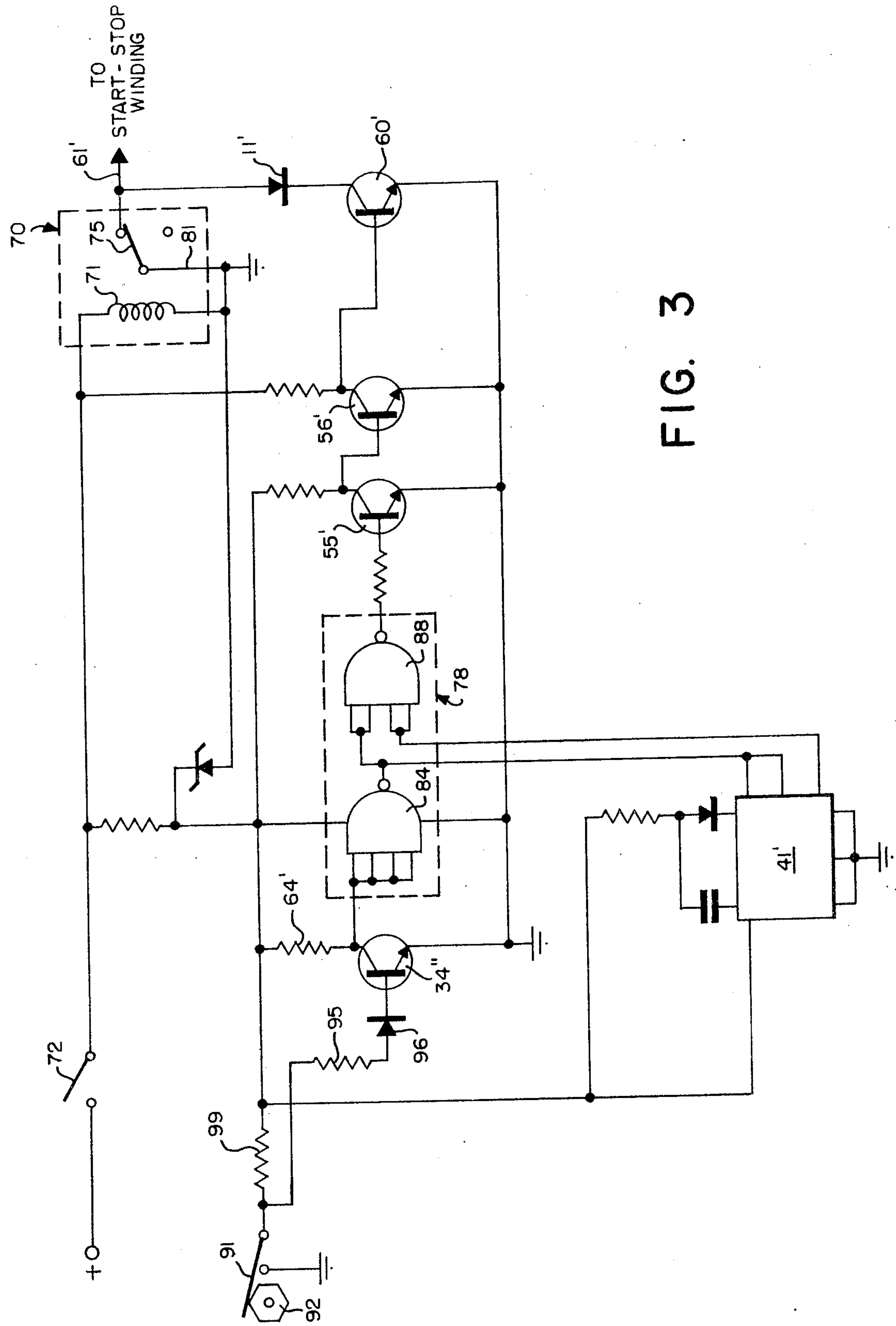
TO START-STOP WINDING
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FIG. 3