May 11, 1965 B. J. DOWNS 3,182,649

ELECTRICAL CONTROL SYSTEM

Filed Dec. 4, 1961

FIG. 1

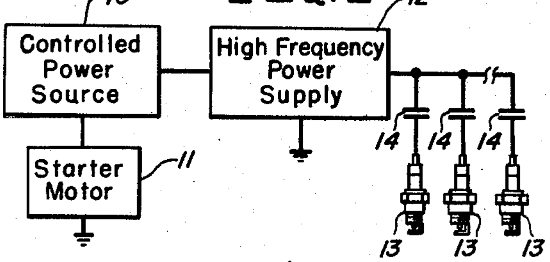


FIG. 4

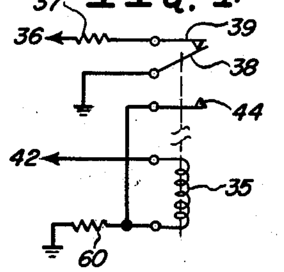


FIG. 2

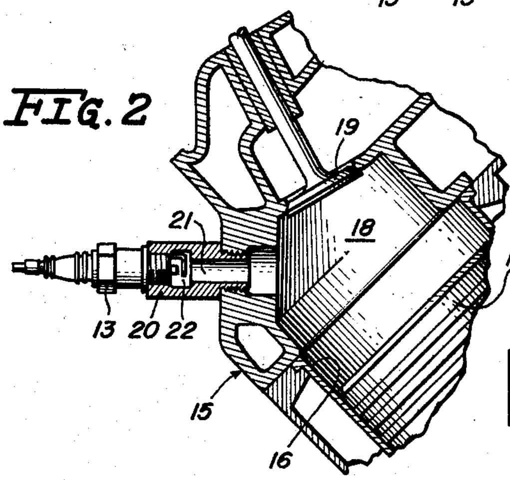


FIG. 5

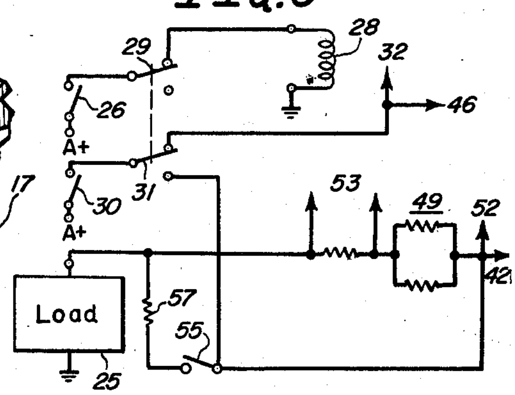
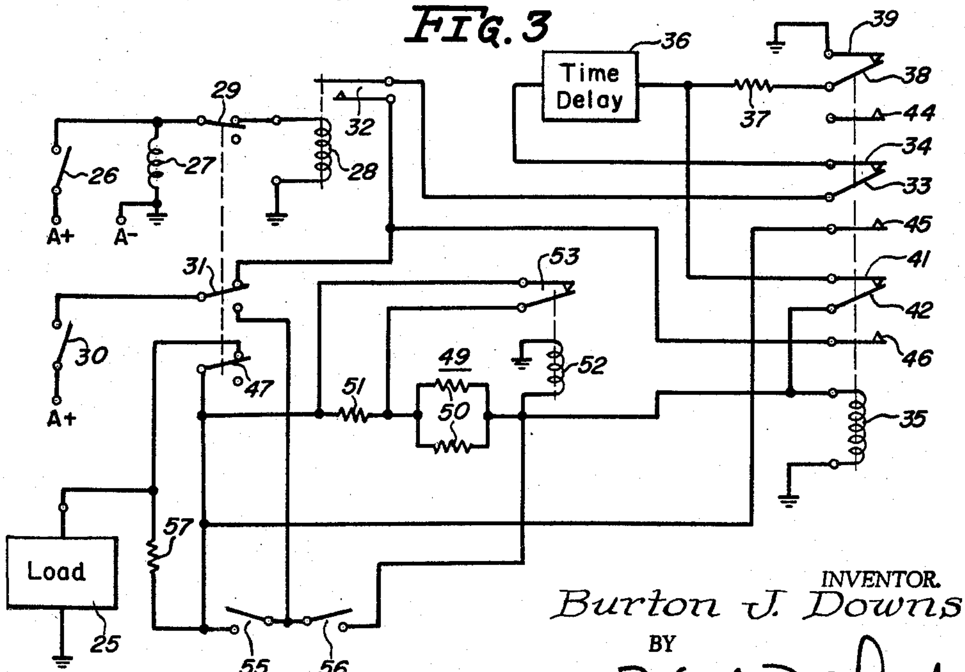


FIG. 3



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ELECTRICAL CONTROL SYSTEM

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The present invention concerns an electrical control system. More particularly, it pertains to a control system capable of energizing a load which requires different energization levels in accordance with an assigned schedule.

Widely different apparatus necessitate the supply of energization in accordance with particular schedules. In such diverse fields as those involving electronic camera circuits, computers, rolling-mill driving apparatus, internal combustion engine ignition systems, and automation generally, indiscriminate application of energizing power may cause inefficient or improper operation. While the control system of the present invention has ready application to more than one such apparatus, it has found extensively tested and proved practicality as part of an ignition system for internal combustion engines, and it therefore will be described in that connection for ease of understanding.

One of the more dramatic new ignition systems disclosed in recent times is that of the type disclosed in United States Patents Numbers 2,866,447 and 2,866,839, issued to Frank J. Kaehni. The Kaehni system supplies igniting power to an internal combustion engine without utilizing a distributor and without the need for interrupting or breaker points. So wedded have these last mentioned items become to the automotive and related trades that it is a distinct lesson in human experience to view and hear the utter disbelief of veteran engine mechanics upon initial exposure to an engine having no distributor. Despite such natural disbelief in the possibility, the very real Kaehni system has been found to perform admirably in a number of operating tests. For example, the June 1959 issue of "Fleet Owner," a McGraw-Hill publication, reports at some length on the arduous road test success of the Kaehni system in such vehicles as ready-mix concrete trucks, moving vans, passenger buses and the like. Engines operated with this ignition system have been found, upon subsequent dismantling, to exhibit evidence of essentially complete combustion during operation. Such findings positively support the conclusions that the Kaehni system not only is superior in eliminating those portions of the conventional ignition system which are most subject to wear but that the quality of performance and consequent efficiency are of the highest order.

The aforedescribed success of this new system has not been achieved without some difficulty. The energy supplied to the combustion igniting means of the engine, typically spark plugs, is in the form of a continuous high frequency potential. One of the leading problems encountered in the system has been difficulty of starting. This problem has included failure to start as well as the development of the condition of pre-detonation or "surface ignition," resulting in bucking of the engine. This latter condition is extremely undesirable in that pre-detonation can result in physical destruction of the engine parts. Another problem has been inefficient utilization of the high frequency power supply energy. As a result, the heat dissipation of such power supplies has been excessively large, requiring such special treatment as oil-bath cooling, large heat sinks, and the like. It is to be noted that load systems other than internal combustion engine ignition arrangements also are subject to similar problems.

It is accordingly a general object of the present invention to provide a control system which obviates one or more of the afore-noted deficiencies or problems.

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Another object of the present invention is to provide a control system which enables proper starting of a continuous ignition system on an internal combustion engine.

A further object of the present invention is to provide a control system for the ignition of internal combustion engines which exhibits improved efficiency with resultant decreased energy waste.

Still another object of the present invention is to provide a new and improved control system capable of delivering energy to a load demanding specially scheduled energization.

A still further object of the present invention is to provide a control device for the described continuous ignition system employed with an internal combustion engine in a manner such that the system exhibits improved efficiency together with operating characteristics proper for satisfactory and worthwhile performance.

Yet another object is to provide a continuous ignition system with safeguards against starting of the engine without intentional actuation of the starter control.

A control system constructed in accordance with the present invention comprises first and second sources of electrical energy together with a load system which upon actuation requires a delay interval before at least maximum energization. The system also includes means responsive to energy from the first source for applying energy from the second source to the load system upon termination of the delay interval.

As applied particularly to engine systems, apparatus incorporating the invention includes an internal combustion engine having a predetermined starting inertia and a combustion igniting means. The system includes means for energizing the combustion igniting means together with a starter coupled to the engine and capable of overcoming the engine's starting inertia. The system also includes means for energizing the starter and means responsive to energization of the starter for delaying energization of the combustion igniting means for a delay interval until the starter overcomes a predetermined portion of the inertia of the engine.

Also included within the ambit of the invention are means for controlling and varying the application of energy to the various components in accordance with those schedules which enable the load apparatus to perform most advantageously. These embellishments upon the fundamental concepts presented enable optimum performance under a variety of operating conditions.

The features of the invention which are believed to be novel are set forth with particularity in the appended claims. The organization and manner of operation of the invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in conjunction with the accompanying drawings, in which like reference numerals refer to like elements in the figures, and in which:

FIGURE 1 is a schematic illustration, partially in block diagram form, illustrating one embodiment of the present invention as applied to internal combustion engines having a continuous ignition system;

FIGURE 2 is a fragmentary cross-sectional view of an internal combustion engine, the combustion of which is initiated by the system shown in FIGURE 1;

FIGURE 3 is a schematic diagram of a control system constructed in accordance with the present invention;

FIGURE 4 is a schematic diagram of a modification of a portion of the system shown in FIGURE 3; and

FIGURE 5 is a schematic diagram of another modification of a different portion of the system shown in FIGURE 3.

As shown in FIGURE 1 for the purpose of illustrating the present invention, an ignition system is of the type described in the afore-mentioned Kaehni patents but modified to include a controlled power source or control system 10. System 10 is coupled to a starter motor 11 for energizing the latter, under control of the usual ignition and starter switches, and supplies energy to a high frequency power supply 12. Supply 12 when energized feeds continuous high frequency energy to combustion igniting devices or spark plugs 13 coupled individually through respective capacitors 14 to the output of supply 12.

Spark plugs 13 are mounted on an internal combustion engine 15 which in this instance is entirely conventional except for the manner in which plugs 13 are adapted to the engine. Since engine 15 may be of any conventional variety, only a fragmentary portion thereof is shown which includes a piston cylinder 16 in which a piston 17 reciprocates and above which is defined a main combustion chamber 18 which communicates with the usual exhaust and intake passages through valves 19. Plug 13 is mounted in a special fitting 20 which in turn in this instance is secured in the place in which the spark plug normally is seated when the internal combustion engine is fired by a conventional distributor-type ignition system. As explained in more detail in the afore-mentioned Kaehni patents, fitting 20 is hollowed to define an interior recess which constitutes a pre-firing chamber or space 21. If desired, the volume added to the combustion chamber by pre-ignition chamber 21 may be compensated by shaving a few thousandths from the head in order to retain the same compression ratio which existed prior to modification of the engine to utilize the continuous ignition system. Of course, in an engine initially designed for incorporation of the continuous ignition system, the head structure is initially formed to include the desired pre-ignition space.

During operation of engine 15, high frequency energy at a frequency which may be, for example, of the order of 5,000–6,000 cycles per second and of a potential of between 20,000 and 30,000 volts, is developed by supply 12 for application through capacitors 14 continuously, at least throughout a substantial portion of each operating cycle, to spark plugs or igniters 13. Capacitors 14 serve as energy limiters. This system is completely self-timing, requiring no distributor, points, ignition timing gears, spark-advancing means, retarding mechanisms, or the like. The shape and proportioning of pre-ignition chamber 21, believed to be a factor in determining the internal thermal, electrical and chemical properties, and its cooperation with main combustion chamber 18 enables combustion in the latter at precisely the right time and regardless of engine speed or torque. The spark developed across the electrodes 22 of plug 13 is continuous, or at least substantially so, and when the pressure and temperature of the combustible mixture within the main chamber rise, similar conditions of the mixture communicated to the pre-ignition chamber result in a change in the character of the spark as a result of which ignition takes place. There is some indication that, although the supply of energy from source 12 is continuous, the spark may be extinguished during a portion of the cycle. Also, and perhaps alternatively, the spark appears to be highly augmented at the instant of establishment of the flame front in chamber 21. The mixture within the main chamber is not ignited until the piston is optimumly near top dead center of its stroke. Not only does this continuous ignition system eliminate many troublesome components present in the conventional distributor type system, but more efficient combustion results with a consequent decrease of undesired deposits within the engine; in addition, exhaust temperatures are reduced and adequate ignition power is available regardless of engine load and/or speed.

Power supply 12, plugs 13, and engine 15 constitute a load system which is electrically energized and con-

trolled by power source 10. Engine 15 presents to starter motor 11 a predetermined starting inertia and motor 11 is capable of overcoming this starting inertia in a given time delay interval. The characteristics assigned to controlled power source 10 take recognition of these engine operating parameters or requirements and develop the necessary input energy for supply 12 in accordance with a schedule devised to achieve optimum performance and efficiency. One embodiment of controlled power source 10 is illustrated in FIGURE 3 in which the aforementioned load system is indicated by block 25.

Considering more particularly the details of this embodiment as applied to the environment herein presented, a normally open starter switch 26 constitutes a first source of electrical energy connecting a battery, the terminals of which are designated A+ and A−, across the usual starter solenoid 27 (or its relay) which actuates starter motor 11 upon closure of switch 26. In this instance, the negative battery terminal is connected to ground. Switch 26 also serves to impress the battery potential across a relay winding 28, having normally open contacts 32, by way of a normally closed emergency switch 29. An ignition switch 30 also is connected to the battery and together therewith constitutes a second source of electrical energy in the overall control system. After closure of ignition switch 30 and during the time interval in which starting motor switch 26 also is closed, a conductive path is established from the positive battery terminal through a time delay device 36. This path extends from switch 30 over normally closed emergency switch contacts 31, over now closed contacts 32, to device 36 over normally closed contacts 33, 34 of a control relay having a coil 35. Completing this initial energizing circuit is a connection from device 36 to ground through a resistor 37 and a pair of normally closed contacts 38, 39 controlled by coil 35.

While device 36 preferably serves additional purposes to be described, the present consideration is of its function of delaying application of maximum energizing potential to load 25 until starter motor 11 overcomes the starting inertia of engine 15. In a typical automobile installation this delay interval is, for example, of the order of from three-tenths to six-tenths of a second. Upon completion of the delay interval established by device 36, a direct connection is effected through device 36 from contact 34, upon which the full battery potential appears, over normally closed contacts 41, 42 to one end of coil 35 the other end of which is grounded. As explained subsequently, the delay interval preferably is inversely proportioned to the ambient temperature. Energization of coil 35 pulls armatures 33, 38 and 42 in a direction toward contacts 45, 44 and 46, respectively. When armature 33 closes against contact 45, full energization potential is applied to load 25 from ignition switch 30 across contacts 32 and over another pair of normally closed emergency switch contacts 47. All resistive components in the system are at this time by-passed. Upon consequent firing of the engine and opening of starter switch 26, contacts 32 open whereupon the only conductive supply path to load 25 is by way of now closed contacts 42, 46 through a regulator 49. Just prior to opening of contacts 32, this circuit through regulator 49 is effectively shunted by the direct connection over contacts 33, 45 to load 25.

Regulator 49 includes, in the connection between contact 42 and switch 47, a pair of parallel-connected like resistors 50 in series with a resistor 51. From a point between contact 42 and resistors 50 a regulator relay coil 52 is connected to ground. Coil 52 operates a pair of normally closed contacts 53 connected across resistor 51.

In a nominal 12 volt ignition system, in which the battery voltage drops substantially below that value during the energization of starter motor 11 and runs substantially above that value, perhaps up to 15 volts or more, at driving speeds, coil 52 is selected to cause opening of contacts 53 at approximately 14 volts across the coil. This effectively places resistor 51 in the supply circuit to lower the potential applied to load 25 thereby restricting the maximum energy supply to the load. While under starting conditions the battery voltage is well below 14 volts, upon de-energization of the starting motor the battery voltage quickly rises to perhaps 13 volts as a result of rising generator output. In the present instance, resistors 50 are selected to have a value so as to drop the voltage applied to load 25 to approximately 10 volts. Of course, the particular values assigned to resistors 50 and 51 in a given system will depend upon the potential value proper to permit operation of high frequency power supply 12 at optimum efficiency and preferably with minimum heat dissipation. Resistors 50 are provided in parallel combination to enable simple temperature compensation. That is, as the current passed by either resistor increases it tends to increase in resistance value and thereby incur increased heat dissipation at the same time as the other resistor, which then is conducting decreased current, is permitted to cool. This continuous interchange of current and hence of heating in the balanced system permits the selection of low cost components while yet maintaining adequate temperature insensitivity.

Returning to a consideration of time delay relay 36, it preferably is of the series-connected type, such as that disclosed in United States Patent No. 2,103,276—Schmidinger, for reasons of simplicity and ready availability; as will be evident, various other delay devices may be used. The device disclosed in that patent is explained with respect to utility as a signal light flasher as used for example with automotive directional signals. As presently employed, the application of a potential across its terminals results in a voltage drop thereacross so that the connection from the ground side of device 36 through relay contacts 41, 42 to coil 35 and to regulator 49 provides those elements with a substantially lowered voltage. However, the system constants are such that the voltage available at contact 41 slowly increases during the time delay interval in a substantially linear manner. At the conclusion of the time delay interval, main shorting contacts within device 36 close so that the device acts as a direct connection in the circuit. Upon consequent energization of coil 35, contacts 33, 34, as well as contacts 38, 39, are opened whereupon the potential to device 36 is interrupted and it automatically resets to its initial condition. It thereupon is in readiness for recycling, if necessary.

Another preferred characteristic of time delay device 36 is that the amount of time delay be inversely proportional to the ambient temperature. This condition corresponds to the increased starting inertia of the engine under cold-weather conditions and the consequent increase in the interval required for the starter motor to overcome that inertia. The exemplary time delay device adequately satisfies these qualities.

Prior to closure of time delay device 36, the current in the circuit established by contacts 41, 42 is insufficient to energize coil 35. However, the energy supply by way of these same contacts through regulator 49 to load 25 increases during the time delay interval slowly and substantially linearly from zero up to about three volts in the exemplary 12 volt ignition system. This initial energization is insufficient to fire the ignition system but does permit the initiation of operation of high frequency power supply 12, particularly when the latter is of the oscillator type. Upon completion of the time delay interval, the voltage in the exemplary system increases rapidly to approximately 10 volts following which it drops back quickly to perhaps 9 volts. This transient increase to a value slightly in excess of the operating value helps to achieve positive starting. By first comparatively slowly bringing the load system energization potential up to a small but less than operating value, the subsequent abrupt increase to above the operating value results in a reduction of high amplitude transients which otherwise may be harmful to the load system.

As noted, the closure of time delay device 36 causes the impression of the maximum available battery voltage on load 25. However, once the engine is started and starter switch 26 is opened the load must derive its energy by way of regulator 49. As soon as starter switch 26 is opened, to in turn open contacts 32, or when contacts 33, 34 open, time delay relay 36 resets to its initial condition. However, contacts 42, 46 must close prior to the opening of starter switch 26, contacts 33, 34 and contacts 38, 39 in order to hold the relay of coil 35 in its energized condition.

The arrangement of the present embodiment further contributes to the suppression of high amplitude transients by the closing sequence of the contacts actuated by coil 35. The various contact over travel is adjusted so that while coil 35 is attracting its armatures, and until contacts 42, 46 close to snap this relay to its energized position, contacts 38, 39, as well as contacts 33, 34, remain closed until after positive engagement of armatures 33, 42 respectively with contacts 45, 46. The result of this over travel or overlap of the initially closed contacts is to leave resistor 37 and the resistance of time delay relay 36, as well as the resistance of coil 35, across the load energizing circuit for a brief period of time following termination of the time delay interval so as to serve as surge suppressors.

Since time delay device 36 as embodied is of the series-connected temperature-operated kind, it will be appreciated that the value of resistor 37 may be adjusted to determine precisely the time delay interval. The value of resistor 37 also has an effect upon the abruptness of the closing of main control relay. In addition, resistor 37 serves a current limiting function to prevent overheating of the elements in device 36. As pointed out, resistor 37 is in parallel with the coil of relay 35 until the latter is fully energized and therefore serves a significant surge suppressing function.

An added feature of the system under discussion is its characteristic of recycling in case engine 15 bucks upon starting. Bucking is generally understood to be caused by pre-detonation of the mixture in chamber 18 with possible resultant damage to the engine elements and interference with desired starting. When bucking occurs, the consequently stalled starter motor drastically lowers the available battery voltage. In recognition thereof, the control system includes means for, in effect, opening all circuits and thereby returning all conditions to the pre-starting situation. To this end, relay 28 is assigned a characteristic such that it drops out or reopens contacts 32 upon a drop in the battery supply potential below approximately 6 volts in the assumed 12 volt nominal system. An analogous result is achieved by assigning to coil 35 a similar release or drop out value. Similarly, substantially the same protection is afforded by using a drop-out relay sensitive directly to an overload of current in the starter system.

The relay of coil 28 serves the additional function of isolating starter solenoid 27 from the control system circuitry thereby to prevent undesired circuit feedback. In some starter motor installations the electrical connections are such as to permit an undesired return path to ground by way of either the starter solenoid or possibly the motor windings themselves. Such conditions of course may be eliminated by the provision of extra contacts on the starter solenoid relay. Alternatively, isolation can be provided in the ignition switch structure itself. Coil 28 and its associated contacts may be eliminated and the bucking threshold function transferred to the relay of coil 35 in cases where the starter motor and solenoid system is properly designed to avoid the inclusion of undesired circuit feedback paths.

The presently described system offers the added advantage that it may be entirely bypassed by simple switch means to permit emergency operation in case of failure of any of its components. This is the purpose of emergency switch contacts 29, 31 and 47 which upon failure of the control system are switched from the condition illustrated in FIGURE 3. As so adjusted, the control system is disabled and battery power is available through the armature of switch **31** to the armatures of a start switch **55** and a run switch **56**. Closure of start switch **55** applied to the full battery potential through a resistor **57** to load **25**, thereby enabling starting of the load under manual control of switch **55**. As soon as combustion is ignited, run switch **56** may be closed, as long as regulator **49** continues to operate satisfactorily, so as to feed the potential derived by way of contact armature **31**, over switch **56**, through regulator **49**, and to load **25** by way of resistor **57**. Resistor **57** is provided in this instance to drop the available battery voltage to the desired starting potential of approximately 9 or 10 volts in the nominal 12 volt system; in many applications it may be eliminated. It should be recognized that this mode of emergency operation may require several attempts at starting before success because of the absence of the desirable control effects afforded by the entire system of FIGURE 3. In addition, operation under these emergency conditions may not permit operation of load **25** under conditions of optimum efficiency or performance.

A modification of the circuit of FIGURE 3 is depicted in FIGURE 4 and features an arrangement for increasing the abruptness of the closure of the relay actuated by coil **35**. To this end, coil **35** is made more sensitive and its connection to ground includes a series connected resistance **60** so that prior to switching of the armatures controlled by coil **35** its operation is the same as that described with respect to FIGURE 3. In this modification, however, resistor **37** is connected to upper contact **39** while the ground return is by way of armature **38**. Contact **44**, unused in the system of FIGURE 3, is returned to the end of resistor **60** remote from ground. Upon energization of coil **35** following the time delay established by device **36**, closure of armature **38** against contact **44** effectively cuts resistor **60** from the circuit and thereby results in an abrupt increase in the potential across **35** to enhance its snap action.

A simplifying alternative of the FIGURE 3 system is illustrated in FIGURE 5. In this instance, emergency switch contacts **47** have been eliminated as has running switch **56** of FIGURE 3. Closure of start switch **55** applies a potential from battery **30** directly over resistor **57** to load **25**. Upon starting, switch **55** is again opened whereupon the power supply is necessarily by way of regulator **49**. During closure of switch **55**, the connection of regulator **49** in parallel with resistor **57** has insignificant effect because of the higher series resistance of the regulator as compared with that of the resistor.

Of course, various simplifications and/or alternatives of the illustrated circuitry may be employed while still incorporating the principal features of the invention. For example, contacts **38**, **39** and **44** may be dispensed with by terminating resistor **37** directly to ground; in many applications the performance will be about the same. Although regulator **49** is most beneficial in a substantial number of systems, its function is often only in the nature of an improvement which may be eliminated when circumstances so warrant.

The controlled power source of the present invention enables a high degree of improvement in the operation of continuous ignition systems as well as other systems presenting similar energization requirements. In use in connection with the continuous ignition systems, the present control system has been found to result in a substantial decrease in heat dissipation of the high frequency power supply. Consequently, previously required oil cooling for that supply has been eliminated. Also, with typical transistorized oscillator-type high frequency power supplies, the need for massive heat sinks for the transistors has been directly eliminated. The anti-bucking features of the circuit not only prevent damage to the different components but also allow an immediate restarting attempt. From the long range view point, the utilization of the present control system with a continuous ignition arrangement enables decreased maintenance, increased efficiency of operation, and greater reliability of performance.

The system also prevents unintended false starting. Many engine systems having automatic transmissions incorporate a safety switch to prevent application of power to the starter motor except when the transmission is in a neutral position. However, on occasions when piston position and other factors are just right, engines have started without aid from the starter motor. This, of course, can be dangerous when the transmission is not in neutral, particularly in the case of continuous ignition systems which often are started with the throttle about half open. Such a result cannot occur with the system of the present invention.

While particular embodiments of the present invention have been shown and described, it is apparent that changes and modifications may be made without departing from the invention in its broader aspects. The aim of the appended claims, therefore, is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. A control system comprising: a first source of electrical energy; a second source of electrical energy; a load system which upon actuation initially requires finite energization of no more than a given level and after a delay interval requires energization at a substantially greater level; means responsive to energy from said first source for applying energy of no more than said given level from said second source to said load system during said interval; and means responsive upon termination of said delay interval for abruptly increasing the level of the energy supplied to said load from said second source substantially above said given level.

2. A control system comprising: a first source of electrical energy; a second source of electrical energy; a load system which upon actuation initially requires finite energization of no more than a given level and after a delay interval requires energization at a substantially greater level; means responsive to energy from said first source for applying energy of no more than said given level from said second source to said load system during said interval; means responsive upon termination of said delay interval for abruptly increasing the level of the energy applied to said load from said second source substantially above said given level; and means for maintaining substantially constant the energy level supplied to said load system upon termination of said interval.

3. A control system comprising: a first source of electrical energy; a second source of electrical energy; a load system which upon actuation initially requires finite energization of no more than a given level and after a delay interval requires energization at a substantially greater level; means responsive to energy from said first source for applying energy of no more than said given level from said second source to said load system during said interval; means responsive upon termination of said delay interval for abruptly increasing the level of the energy applied to said load from said second source substantially above said given level; and means responsive to a substantial decrease in the energy level available to said load system from one of said first and second sources for interrupting energization of said load system.

4. A control system comprising: a first source of electrical energy; a second source of electrical energy; a load system which upon actuation initially requires finite energization of no more than a given level and after a delay interval requires energization at a substantially greater level; means responsive to energy from said first source for applying energy of no more than said given level from said second source to said load system during said interval; and means responsive upon termination of said delay

interval for abruptly increasing the level of the energy applied to said load from said second source substantially above said given level, the length of said delay interval being inversely proportional to the ambient temperature.

5. A control system comprising: a first source of electrical energy; a second source of electrical energy; a load system which upon actuation requires a delay interval before at least maximum energization; control means responsive to energy from said first source for applying energy from said second source to said load system upon termination of said delay interval; and means for quickly restoring said control means to its initial condition upon termination of said delay interval, while maintaining energization of said load system from said second source.

6. A control system comprising: a first source of electrical energy; a second source of electrical energy; a load system which upon actuation requires a delay interval before at least maximum energization; control means responsive to energy from said first source for applying energy from said second source to said load system upon termination of said delay interval; means responsive to a substantial decrease in the energy level available to said load system from one of said first and second sources for automatically interrupting energization of said load system; and means for automatically isolating said control means from said first source upon interruption of said load-system energization.

7. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means which initially requires finite energization of no more than a given level and after a delay interval requires energization at a substantially greater level; means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; and means responsive to energization of said starter for causing initial energization of said combustion igniting means at a finite energy level no greater than said given level and delaying energization of said combustion igniting means at said substantially greater level for an interval until said starter overcomes said predetermined inertia.

8. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means located in an auxiliary ignition chamber, separate from but connecting with the power-developing primary ignition chamber of said engine, firing automatically in timed relation with respect to operation of said engine while continuously energized with radio frequency energy; means for energizing said combustion igniting means with continuous radio-frequency energy; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; and means responsive to energization of said starter for delaying energization of said combustion igniting means for an interval until said starter substantially overcomes said predetermined inertia.

9. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having a combustion igniting means located in an auxiliary ignition chamber, separate from but connecting with the power-developing primary ignition chamber of said engine, automatically firing in timed relationship to the operation of said engine while subjected to continuously applied radio-frequency energy; means for energizing said combustion igniting means with continuous radio-frequency energy; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; means responsive to energization of said starter for delaying energization of said combustion igniting means for an interval until said starter overcomes said predetermined inertia; and means responsive to predetonation of said engine for automatically interrupting energization of said combustion igniting means.

10. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having a combustion igniting means; means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; means responsive to energization of said starter for delaying energization of said combustion igniting means for an interval until said starter overcomes said predetermined inertia; and means responsive, after initial energization of said starter, to a decrease below a predetermined value in the level of energization available to said combustion igniting means for automatically interrupting energization of said combustion igniting means.

11. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means; means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; means responsive to energization of said starter for enabling energization of said combustion igniting means; and means responsive, after initial energization of said starter, to a decrease below a predetermined value in the level of energization available to said combustion igniting means for automatically interrupting energization of said igniting means.

12. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means; means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; control means responsive to energization of said starter for delaying energization of said combustion igniting means for an interval until said starter overcomes said predetermined inertia; and means for rapidly restoring said control means to its initial condition upon termination of the delay interval, while maintaining energization of said combustion igniting means.

13. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means located in an auxiliary ignition chamber, separate from but communicating with the power-developing primary ignition chamber of said engine; means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; control means responsive to energization of said starter for delaying combustion-level energization of said combustion igniting means for a delay interval until said starter overcomes said predetermined inertia; and means for conditioning said control means to apply energy to said combustion igniting means of a finite value but less than that required for ignition during the delay interval and upon the conclusion of said interval abruptly increasing said energy to a level at which substantially optimum ignition occurs.

14. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means located in an auxiliary ignition chamber, separate from but connecting with the power-developing primary ignition chamber of said engine; means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; control means responsive to energization of said starter for delaying combustion-level energization of said combustion igniting means for a time delay interval until said starter overcomes said predetermined inertia; and means for conditioning said control means to apply energy to said combustion igniting means of a finite value approximately one-fourth that required for optimum ignition during the delay interval and upon conclusion of said interval abruptly increasing said energy to a level at which substantially optimum ignition occurs.

15. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means located in an auxiliary ignition chamber, separate from but communicating with the power-developing primary ignition chamber of said engine; means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; control means responsive to energization of said starter for delaying combustion-level energization of said combustion igniting means for a delay interval until said starter overcomes said predetermined inertia; and means for conditioning said control means to apply energy to said combustion igniting means of a finite value but less than that required for ignition during the delay interval and upon conclusion of said interval abruptly increasing said energy to a level above that at which ignition occurs and then reducing said level to an operating value.

16. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means; means for energizing said combustion igniting means located in an auxiliary ignition chamber, separate from but communicating with the power-developing primary ignition chamber of said engine; a starter coupled to said engine and capable of overcoming said starting inertia; means for energizing said starter; means responsive to energization of said starter for delaying combustion-level energization of said combustion igniting means for a delay interval until said starter overcomes said predetermined inertia; and regulating means for maintaining substantially constant the energy level supplied to said combustion igniting means subsequent to said delay interval.

17. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means; means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; power means for energizing said starter; control means responsive to energization of said starter for delaying energization of said combustion igniting means for a delay interval until said starter overcomes said predetermined inertia; means responsive to predetonation of said engine for automatically interrupting energization of said combustion igniting means; and means for automatically isolating said control means from said power means upon actuation of said interrupting means.

18. An engine system comprising: an internal combustion engine having a predetermined starting inertia and having combustion igniting means; control means for energizing said combustion igniting means; a starter coupled to said engine and capable of overcoming said starting inertia; power means for energizing said starter; means responsive to predetonation of said engine for automatically interrupting energization of said combustion igniting means; and means responsive to energization of said starter for delaying energization of said combustion igniting means for a delay interval until said starter overcomes said predetermined inertia, said interrupting means automatically isolating said control means from said power means upon actuation of said interrupting means.

19. A control system comprising: a first source of electrical energy; a second source of electrical energy; a load system which upon actuation requires a delay interval before at least maximum energization; means responsive to energy from said first source for applying energy from said second source to said load system upon termination of said delay interval; and means in said control system for suppressing energy transients during the initial application of said energy from said second source to said load system.

20. A control system comprising: a first source of electrical energy; a second source of electrical energy; a load system which upon actuation requires a delay interval before at least maximum energization; means responsive to energy from said first source for applying energy from said second source to said load system upon termination of said delay interval; and regulating means for maintaining substantially constant the energy level supplied to said load system upon termination of said interval, said regulating means including a primary energy path comprising a pair of parallel connected impedances of approximately equal value.

21. An engine system comprising:
an internal combustion engine having a predetermined starting inertia and having combustion igniting means;
control means for energizing said combustion igniting means;
a starter coupled to said engine and capable of overcoming said starting inertia;
power means for energizing said starter motor;
means for supplying energy to said control means and to said power means;
and means sensitive to a decrease below a predetermined amount in the level of energy available to said combustion-igniting means in response to an increase in the level of energy supplied to said starter motor for increasing the level of energy supplied to said combustion-igniting means during operation of said starter motor.

22. An engine system comprising:
an internal combustion engine having a predetermined starting inertia and having combustion-igniting means;
control means for energizing said combustion-igniting means;
a starter coupled to said engine and capable of overcoming said starting inertia;
means for supplying energy to said control means and to said starter;
and voltage-sensitive circuit means connected directly in an energy-flow path between said energy-supplying means and said combustion-igniting means, said voltage-sensitive means responsive to a decrease in potential supplied by said energy-supplying means below a predetermined amount, including the occurrence of such decrease during operation of said starter motor, for increasing the level of energy supplied to said combustion-igniting means during said decrease of said potential below said predetermined amount.

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