

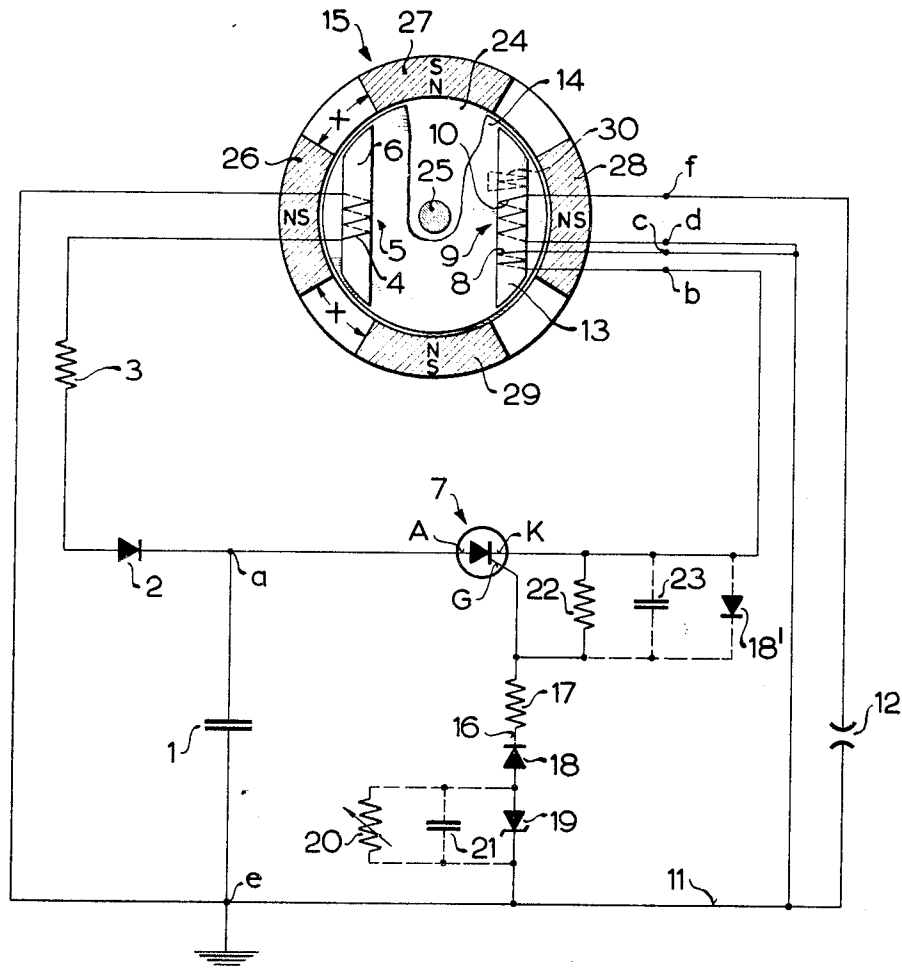
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# IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES

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## IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES

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### ABSTRACT OF THE DISCLOSURE

An electronic circuit arrangement for firing spark plugs in internal combustion engines. A capacitor stores the energy for firing the spark plugs during one portion of the operation cycle. This energy is supplied to the capacitor by a charging coil operating in conjunction with a movable magnetic system. A semi-conductive control rectifier or thyristor discharges the energy from the capacitor in a controlled manner. The discharge from the capacitor is applied to the primary winding of an ignition transformer whose secondary winding is connected across the spark plug to be fired. Both the charging coil and the ignition transformer have ferromagnetic cores magnetically linked with the movable magnetic system. The latter moves a series of permanent magnets past the ferromagnetic cores to influence them in an alternating manner. Electronic circuit components are associated with the electronic switching element in the form of semiconductor rectifiers so as to assure reliable operation.

### BACKGROUND OF THE INVENTION

Ignition arrangements of the species of the present invention are used in cases where no battery is available to provide energy for the ignition arrangement. Through storage of the ignition energy in the associated capacitor, a high voltage impulse with steep front or rising edge is realized in the secondary winding of the ignition transformer at the instant of ignition. As a result of this arrangement the spark plugs receive an electrical spark jump in a reliable manner even when the electrodes of the spark plugs are severely soiled. In accordance with the present invention it is possible to omit any mechanical switching element. Mechanical switches tend to become easily soiled through oil deposits or the like, and thereby interfere with reliable operation of the ignition arrangement.

In the German Patent 1,228,461, an ignition arrangement is disclosed in which the voltage for the controlled electrode of the associated electronic switch is derived from a charging coil wound in a predetermined manner or sense. As a result of this arrangement, the voltage for the control electrodes of the electronic switch as well as the charging voltage for the ignition capacitor have both the same origin or initial instant and the same phase. In order to realize an optimum ignition voltage impulse, the ignition capacitor must be fully charged at the instant at which the discharge process begins. This is the case when the charging voltage in the form of a half-wave is operative until it reaches its maximum value at the ignition capacitor. This requires that the circuit path of the electronic switch be in the conductive state even precisely at the point of the optimum value of the charging voltage. It is not possible, however, to realize this condition with reliability

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and assurance because the voltage function in the region of the optimum value is relatively flat. Accordingly, a voltage value prior to that of the peak can be sufficient to switch or reverse the electronic switch. Aside from this the undesirable condition prevails that the magnitude of the voltage will not be sufficient for the switching operation when the speed of the internal combustion engine is relatively low. It is, furthermore, undesirable that the charging coil continues to provide voltage during the discharge of the ignition capacitor.

Accordingly, it is an object of the present invention to provide an ignition arrangement in which the undesirable features associated with the conventional arrangement is avoided.

The object of the present invention is achieved through the arrangement in which the charging coil as well as the ignition transformer, under the influence of a magnetic system are used for providing the voltage to the control electrode of the electronic switch. The charging coil and the ignition transformer are each mounted on a ferromagnetic core which is alternately influenced through the magnetic system.

### SUMMARY OF THE INVENTION

An ignition arrangement for firing spark plugs in internal combustion engines. The energy for firing the spark plugs is stored within an ignition capacitor which is charged through a charging coil. The latter is mounted on a ferromagnetic core and is connected to the ignition capacitor. The capacitor is discharged by way of a controllable electronic switch in the form of a semi-conductor controlled rectifier or a thyristor. This electronic switching means provides for controlled discharge of the ignition capacitor. The discharge from the capacitor, by way of the electronic switch, is applied to the primary winding of an ignition transformer. The secondary winding of this transformer is connected to the spark plug to be fired. The ignition transformer has a ferromagnetic core which is magnetically isolated from the ferromagnetic core upon which the charging coil is wound. A movable magnetic system of permanent magnets moves through the magnetic circuit path of the charging coil and the ignition transformer so as to influence them in an alternate manner.

The novel features which are considered as characteristic for the invention are set forth in particular in the appended claims. The invention itself, however, both as to its construction and its method of operation, together with additional objects and advantages thereof, will be best understood from the following description of specific embodiments with reference to the accompanying drawing.

### BRIEF DESCRIPTION OF THE DRAWING

A functional and electrical schematic diagram showing the electronic components and the magnetic parts as well as their interrelationships and interconnections for providing a ignition arrangement to fire spark plugs in an internal combustion engine, in accordance with the present invention.

### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the ignition arrangement shown in the drawing, the ignition energy is stored in an ignition capacitor 1. This ignition capacitor is connected to the series circuit of a charging rectifier 2, a limiting resistor 3, a winding 4 of a charging coil 5, and a ferromagnetic core 6 within the coil 5. The circuit junction  $a$  is also

connected to the path A-K of a control electronic switch 7 which is, in turn, connected to the primary winding 8 of an ignition transformer 9, by way of the circuit point *b*. The circuit point or junction *a* is of positive potential. The other end *c* of the primary winding 8 is connected to one end *d* of the secondary winding 10 of the ignition transformer 9 and, at the same time, to the circuit junction *e* by way of a path 11. The circuit junction *e* of the ignition capacitor 1 is of negative potential. A spark plug 12 is connected across the terminals of the secondary winding 10 of the ignition transformer 9, through the coil terminals *d* and *f*. The secondary winding of the ignition transformer 9 has a ferromagnetic core 13. The charging coil 5 as well as the transformer 9 are mounted upon a mounting plate which is of non-magnetic material. A magnetic system 15 driven by the internal combustion engine, not shown, moves relative to the assembly of the mounting plate 14 and the charging coil with the ignition transformer 9.

The ignition transformer 9 is used for purposes of delivering the control voltage for the control electrode G of the electronic switch 7. The charging coil and ignition transformer 9 are mounted on ferromagnetic cores 6 and 13 which are magnetically isolated from each other. The ferromagnetic cores 6 and 13 are alternately influenced through the magnetic system 15. A very simple embodiment is achieved, for example, through the use of the primary winding 8 of the ignition transformer 9 for purposes of generating the voltage for the control electrode G of the electronic switch 7. By way of the circuit path 11, the control electrode G leads to the terminal *c* of the primary winding 8 of the ignition transformer 9. The terminal *c* also leads, by way of the circuit path 11, to the circuit junction or point *e*.

The control electrode G and the circuit path 11 is a limiting resistor 17, a connection 16 leading to the diode 18, and a switching element 19, connected to switch at a predetermined threshold value.

Since the diode 18 has itself a low threshold value, the switching element 19 may be avoided when this threshold value is sufficient for maintaining proper operation. The switching element 19, can, for example, be in the form of a Zener diode which conducts at a predetermined voltage level. The Zener diode may also be replaced, for example, by a nonlinear resistor or a voltage source so as to oppose the control voltage. At the same time, the switching element 19 may be in the form of a parallel combination of a resistor 20 and a capacitor 21 as shown by the dashed lines in the drawing. This RC network comprises of resistor 20 and capacitor 21 provides a threshold voltage as a function of the rotational speed of the engine.

Connected across the terminals G and K of the electronic switch 7 is a resistor 22. The operation of the electronic switch 7 becomes more reliable when a capacitor 23 is connected across the resistor 22 as shown by the broken lines in the drawing. If, further a diode 18' is connected across a capacitor so that its cathode is coupled to the control electrode G the diode 18 in the circuit connection 16 may be omitted.

The magnetic system 15 has a movable disc 24 mounted upon a shaft 25 driven by the crank shaft of the combustion engine. At its periphery, the movable disc 24 includes four permanent magnets 26, 27, 28 and 29. The permanent magnets 26, 27, 28, and 29 are separated from each other by equal spaces *x*, and are moved past the ferromagnetic cores 6 and 13 through rotation of the disc 24. The ferromagnetic cores 6 and 13 are dimensioned so that each one of its poles may lie in one of two neighboring spaces *x*. Of the four magnets 26, 27, 28 and 29, the three magnets 27, 28 and 29 face the ferromagnetic core 6 and 13 with their north poles *N*. The magnet 26, on the other hand, faces the ferromagnetic cores 6 and 13 with its south pole *S*. As a result of this arrangement, particularly shaped pulses are realized for the pur-

pose of charging the ignition transformer 1 and the controlling of the electronic switch 7.

When required, the ignition transformer 9 may be provided with a short circuit winding 30 as shown by the broken lines in the drawing.

In operation, assume first that the magnetic system 15 is rotated and the two neighboring spaces *x* adjacent to the magnet 26 lie opposite to the ends of the ferromagnetic core 6 of the charging coil 5. As a result of the relative motion, a severe variation in the magnetic flux linking the core 6 prevails. This flux variation gives rise to an effective voltage pulse in the winding 4 of the charging coil 5. The induced voltage pulse is of the polarity for transmission through the charging rectifier 2. The ignition capacitor 1, therefore, becomes charged through the rectifier 2 and the limiting resistor 3. After being fully charged, the energy of the ignition capacitor 1 is available for electrical ignition purposes, whereby the junction *a* is of positive potential and the junction *e* is of negative potential. If now, the adjacent spaces *x* of the magnet 26 move relative to the core 13 so that they lie opposite the ends of this core, a control voltage pulse is induced as a result of the severe variation in the magnetic flux accompanying the relative motion. This, control voltage pulse is applied to the terminals G and K of the electronic switch 7, so that the control electrode G acquires a positive potential in relation to the cathode electrode K. As a result, the circuit A-K is situated in the conducting state. During this set of conditions, the ignition capacitor 1 can be discharged through the circuit path A-K of the electronic switch 7 and the primary winding 8 of the ignition transformer 9. This gives rise to a high voltage impulse in the secondary winding 10 of the ignition transformer 9. This voltage impulse causes an electrical spark to jump across the electrodes of the spark plug 12. A charge and discharge cycle of this type, then occurs with every rotation of the magnetic system 15.

With the rotation of the magnetic system 15 voltage pulses also arise which have polarity opposite to that associated with the charging or control voltage. These pulses of such opposite polarity are, however, suppressed through the diodes 18 or 18' in the control circuit of the electronic switch 7. In the charging circuit, of the ignition capacitor 1 these voltage pulses are suppressed through the voltage rectifier. Thus, the diode 18 or 18' assures that only positive control signals are applied to the control electrode G of the electronic switch 7.

The switching element 19 with an associated threshold voltage, assures also that no positive undesirable oscillations reach a control electrode G of the electronic switch 7. Such noise signals or oscillations cannot exceed the threshold value. The actual control pulse is made large in relation to the preestablished threshold voltage so that this control pulse is transmitted reliably by the switching element 19.

Through means of the capacitor 23, high frequency noise or oscillations can be conducted from the control electrode G to the cathode K of the electronic switch 7 and thus rendered ineffective.

With the aid of the resistors 17 and 22 the value of the control potential is precisely established.

The ignition arrangement in accordance with the present invention has the particular advantage that the control voltage for the control electrode G of the electronic switch 7 rises faster with increased speed of the internal combustion engine. As a result the instant of ignition becomes automatically advanced. This is desirable in engines from the power consumption point of view. In order to prevent undesirable values associated with this advancing of the instant of ignition, it is advantageous to provide an element with the control electrode G of the electronic switch 7, which is associated with a threshold voltage dependent upon the speed of the engine. The RC network comprised of capacitor 21 in parallel with the

resistor 20 is adapted for this purpose. In place of the capacitor 21 and the resistor 20, or in addition to these circuit elements, a short-circuit winding 30 may be provided on the ignition transformer 9.

In the embodiment described, the secondary winding of the ignition transformer 9 includes a single spark plug 12. It would be within the frame of the present invention, however, if the secondary winding would include a plurality of such spark plugs. The ignition impulse in such a case is provided in proper sequence through the conventional distributor. The magnetic system 15 can thereby be transported with corresponding speed or be structurally designed for this purpose.

In the preferred embodiment of the present invention a semiconductor controlled rectifier and, in particular a thyristor is chosen for the electronic switch 7. However, vacuum tube elements or other semi-conductor elements may be used for this purpose.

It is also not absolutely essential that the control voltage for the electrode G of the electronic switch 7 be derived from the primary winding 8 of the ignition transformer 9. It is quite possible to obtain this voltage from a secondary winding 13, or an auxiliary winding (not shown). By providing the proper number of turns on the winding it is possible to realize the desired magnitude of a control voltage.

It is also within the frame of the present invention, to reverse the arrangement whereby the magnetic system 15 is held stationary, and the charging coil 5 as well as the ignition transformer 9, are made rotatable.

It will be understood that each of the elements described above, or two or more together, may also find a useful application in other types of ignition arrangements for internal combustion engines differing from the types described above.

While the invention has been illustrated and described as embodied in ignition arrangements for internal combustion engines, it is not intended to be limited to the details shown, since various modifications and structural changes may be made without departing in any way from the spirit of the present invention.

Without further analysis, the foregoing will so fully reveal the gist of the present invention that others can by applying current knowledge readily adapt it for various applications without omitting features that, from the standpoint of prior art, fully constitute essential characteristics of the generic or specific aspects of this invention and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claim:

1. An ignition arrangement for an internal combustion engine, comprising, in combination, spark plug means; ignition capacitor means for storing energy associated with the firing of said spark plug means; charging coil means on first ferromagnetic core means for charging said ignition capacitor means; magnetic means driven by said engine through the magnetic path of said charging coil means; controllable electronic switching means connected to said ignition capacitor means for providing a controlled discharge path for said ignition capacitor means during triggering; and ignition transformer means having primary and secondary windings on second ferromagnetic core means mounted in the path of said magnetic means, said primary winding being connected to said electronic switching means and thereby connected to said controlled discharge path of said capacitor means during said triggering of said electronic switching means and said secondary winding being connected to said spark plug means, whereby said magnetic means influences alternately the magnetic flux associated with said first and second ferromagnetic core means for inducing a charging voltage within said charging coil means and inducing

a control voltage within said primary winding of said ignition transformer for controlling said controllable electronic switching means, said charging voltage and said control voltage being induced through relative motion between said magnetic means and said ferromagnetic core means.

2. The ignition arrangement as defined in claim 1, including connecting means for connecting said controllable electronic switching means to said primary winding and said ignition transformer means whereby the voltage signal from said primary winding controls said controllable electronic switching means.

3. The ignition arrangement as defined in claim 1, including a control element in said controllable electronic switching means for controlling the same; and connecting means for connecting said control element to said ignition capacitor means and said primary winding of said ignition transformer means.

4. The ignition arrangement for an internal combustion engine as defined in claim 3, including a threshold switching means connected to said control element for applying a threshold voltage to the same.

5. The ignition arrangement for an internal combustion engine as defined in claim 3 including means connected to said control element and providing a threshold voltage to said control element as a function of the speed of said engine.

6. The ignition arrangement for an internal combustion engine as defined in claim 5 including diode means connected to said control element.

7. The ignition arrangement for an internal combustion engine as defined in claim 5, including diode means connected to said control element, said electronic switching means having a signal transmission path controllable by said control element, said diode means being connected across said control element and said signal transmission path.

8. The ignition arrangement for an internal combustion engine as defined in claim 7, including resistor means connected to said control element.

9. The ignition arrangement for an internal combustion engine as defined in claim 7, including auxiliary resistor means connected in parallel with said diode means.

10. The ignition arrangement for an internal combustion engine as defined in claim 9 including auxiliary capacitor means connected in parallel with said auxiliary resistor means.

11. The ignition arrangement for an internal combustion engine as defined in claim 1 wherein said magnetic means comprises movable disc means; and permanent magnetic means mounted at the periphery of said movable disc means, said permanent magnetic means being moved through the magnetic path of said first and second ferromagnetic core means.

12. The ignition arrangement for an internal combustion engine as defined in claim 11, including mounting means for mounting four of said permanent magnetic means on the periphery of said movable disc means, said permanent magnetic means being mounted spaced from each other so that three of said permanent magnetic means lie with their north poles opposite said first and second ferromagnetic means and the fourth one of said permanent magnetic means lies with its south pole opposite said first and second ferromagnetic means, the spaces between said ferromagnetic means being such that said first and second ferromagnetic core means bridges one of said permanent magnetic means.

13. The ignition arrangement for an internal combustion engine as defined in claim 12 including short-circuit winding means wound upon said ignition transformer means.

14. The ignition arrangement for an internal combustion engine as defined in claim 13, including rectifier means connected in series with said charging coil means and to said ignition capacitor.

15. The ignition arrangement for an internal combustion

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tion engine as defined in claim 14, including charging resistor means connected in series with said rectifier means.

References Cited

UNITED STATES PATENTS

2,688,101 8/1954 Harsch et al. 310—70  
3,186,397 6/1965 Loudon 123—148

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3,326,199 6/1967 McMillen 123—148  
3,358,665 12/1967 Carmichael et al. 123—148  
3,367,314 2/1968 Hirosawa et al. 123—148

5 LAURENCE M. GOODRIDGE, Primary Examiner

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