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JÖRG ISSLER

3,280,809

IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES

Filed March 5, 1963

3 Sheets-Sheet 1

FIG. 1

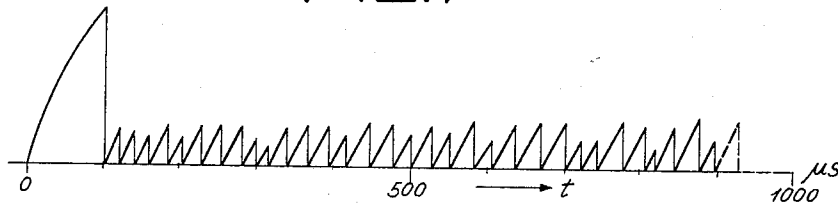


FIG. 2

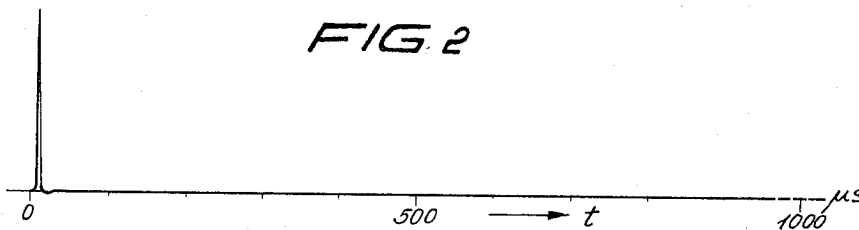
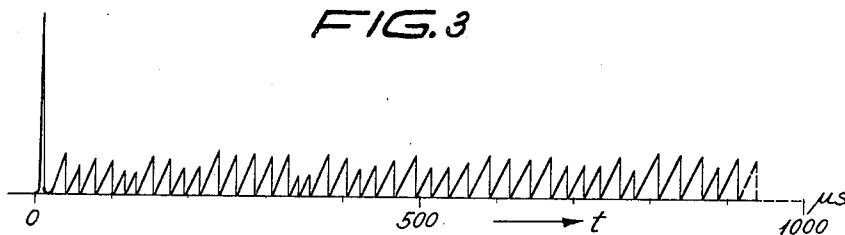


FIG. 3



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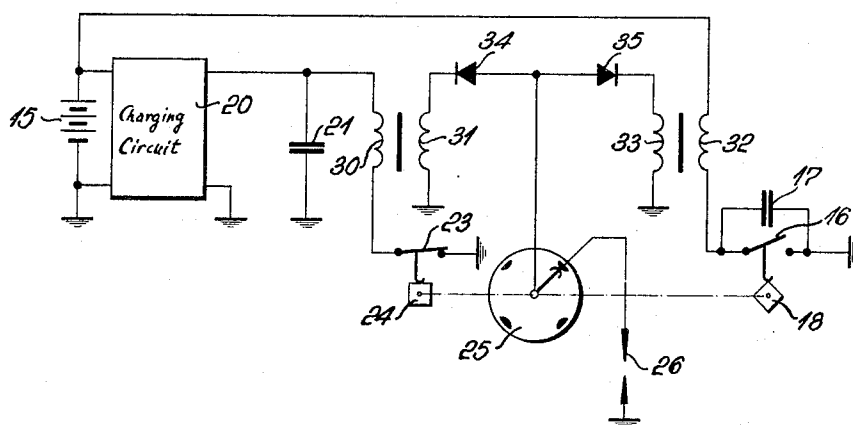
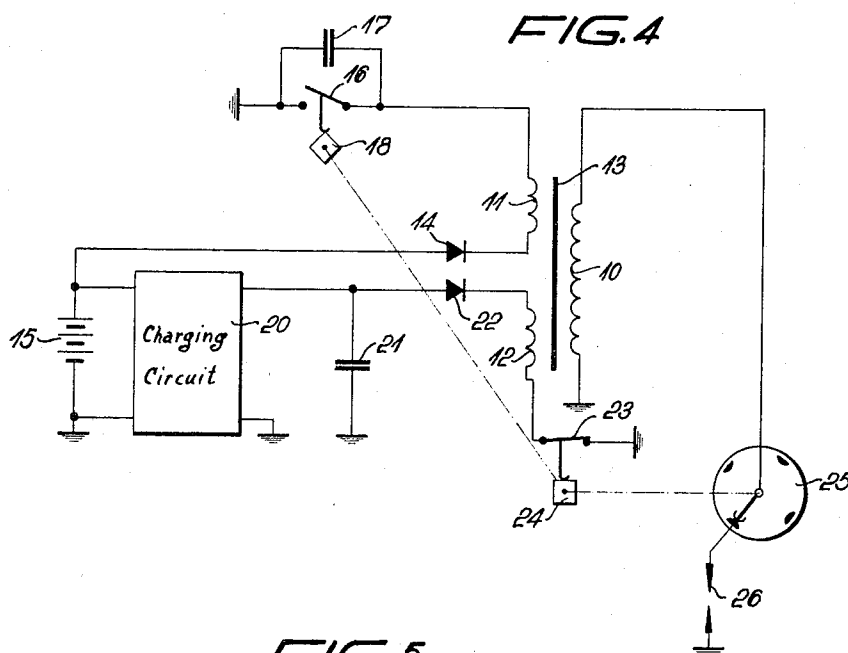
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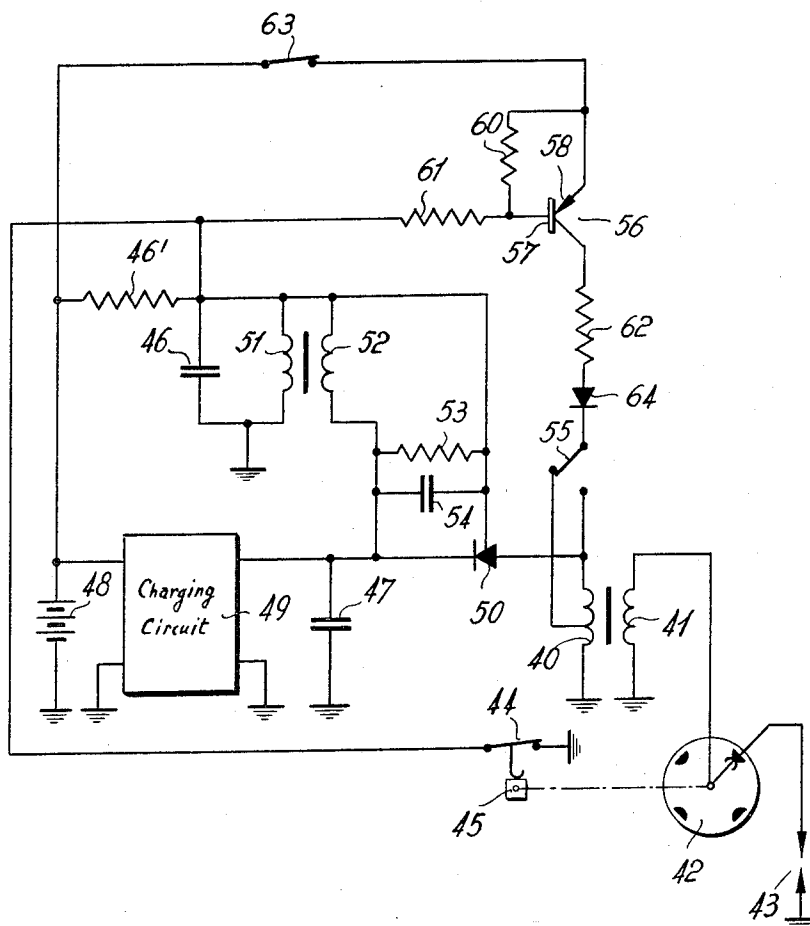
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IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES

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FIG. 6



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IGNITION ARRANGEMENT FOR INTERNAL COMBUSTION ENGINES

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20 Claims. (Cl. 123—148)

The present invention concerns an ignition arrangement for internal combustion engines.

It has been found that there is a demand for improving conventional ignition arrangements because in the operation of certain engines it occurs frequently that the ignition skips or misses which may be due to various different reasons. For instance, the malfunction may be due to carbon deposits or other contaminations of the spark plugs, or it may be due to the fuel-air mixture being inhomogeneous. In both cases these conditions tend to prevent the formation of a spark at the spark plugs. It is evident that means for overcoming the one difficulty would not be suitable for overcoming the other difficulty, and vice versa.

It is therefore an object of this invention to provide for an ignition arrangement which would operate reliably and uniformly under various conditions tending to cause the ignition to skip.

It is another object of this invention to provide for an arrangement of the type set forth which is comparatively simple in structure and entirely reliable in operation.

With above objects in view the invention includes an ignition arrangement for internal combustion engines comprising, in combination, ignition transformer means having primary winding means and secondary winding means; first circuit means connected with at least a portion of said primary winding means and including capacitor means and capacitor charging means for storing electric energy in said capacitor means; second circuit means including a source of electric energy and connected also with at least a portion of said primary winding means for storing magnetic energy therein; ignition impulse output means connected with said secondary winding means of said ignition transformer means for delivering ignition impulses when such impulses are generated in said secondary winding means; and combined control means in both said first and second circuit means for causing at the moments when delivery of ignition impulses are desired the release of said stored electric energy from said capacitor means and of said stored magnetic energy through said secondary winding means so as to generate therein ignition impulses.

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 when read in connection with the accompanying drawings, in which:

FIGS. 1-3 are voltage-time diagrams illustrating the voltage variations appearing at a spark plug, namely FIG. 1 illustrating the conditions prevailing in the case of an induction type ignition arrangement, FIG. 2 illustrating the conditions in the case of a capacitor type ignition arrangement, and FIG. 3 illustrating the conditions obtainable by the arrangement according to the invention;

FIG. 4 is a schematic circuit diagram of one embodiment of the invention comprising an ignition transformer having two primary windings and one secondary winding;

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FIG. 5 is a schematic circuit diagram of another embodiment of the invention comprising two separate ignition transformers; and

FIG. 6 is a schematic circuit diagram illustrating a further embodiment of the invention comprising a single ignition transformer having one primary winding and one secondary winding, and including electronic control means.

In an induction type ignition arrangement a current flowing through the primary winding of the so-called ignition coil is interrupted by the primary current interrupter at the moment when an ignition impulse is desired. By the resulting change of current flow and consequently of the magnetic flux in the coil a voltage is generated by induction in the secondary winding which produces a spark in a spark plug connected with the coil.

FIG. 1 illustrates an oscillogram of the output voltage of an induction type ignition arrangement. The diagram shows that the voltage at the spark plug electrodes rises, when the current flow is interrupted by opening the primary current interrupter, from zero until after about 50-100 microseconds after opening the interrupter this potential collapses on account of the sparkover. As can be seen further from the oscillogram according to FIG. 1 the first discharge of magnetic energy and the corresponding first spark are followed by a substantial number of secondary discharges or sparks which continue through a period of time ranging e.g. between 800 and 1000 microseconds and thereby are well adapted to cause or to facilitate combustion also of fuel-air mixtures which are not easily inflammable. However it is a disadvantage of this type of performance of induction type ignition arrangements that the comparatively slow rise of the voltage at the spark plug electrodes cannot be relied upon to cause ignition of the fuel-air mixture, particularly if the spark plug electrodes are contaminated by carbon deposits or other substances.

On the other hand, the operation of a conventional capacitor type ignition arrangement does not produce any noticeable secondary discharges. The oscillogram of FIG. 2 referring to a capacitor type ignition arrangement illustrates clearly that the voltage at the spark plug electrodes rises very much faster, namely in 2 to 10 microseconds, than is the case in an induction type ignition arrangement as illustrated by FIG. 1. However as can be seen from FIG. 2 practically no secondary discharges follow the first discharge. The very steep rise of the voltage has the favorable effect that a sparkover takes place even if the spark plug electrodes are contaminated by carbon or other deposits. However this highly desirable effect cannot be utilized for causing combustion of weak or poorly mixed fuel-air mixtures.

In contrast therewith, FIG. 3 illustrates the performance of an ignition arrangement according to the invention which produces a combustion of the fuel-air mixture in the cylinders of internal combustion engines irrespective of whether the spark plugs are contaminated or the quality of the fuel-air mixture is unsatisfactory. This highly advantageous effect is due to the fact that the arrangement according to the invention combines the characteristic features both of induction type and capacitor type ignition arrangements. The oscillogram of FIG. 3 shows clearly the steep voltage rise at the start of the capacitor discharge whereby the obstacle of contamination is overcome, and shows also a substantial number of secondary discharges which produce combustion of the fuel-air mixture even if the latter is inhomogeneous or poorly mixed. Such poor fuel-air mixtures may reach the engine for instance when the gas pedal is in an intermediate position. The advantageous effect of the ignition arrangement according to the invention is therefore due to the steep

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rise of the voltage and the following substantial number of secondary discharges.

The performance illustrated by FIG. 3 can be obtained for instance by operating an ignition arrangement as shown in various embodiments of the invention by FIGS. 4-6.

The arrangement according to FIG. 4 comprises an ignition transformer having one secondary winding 10 and two primary windings 11 and 12, all of said windings being wound about an iron core 13.

The primary winding or winding portion 11 serves for storing magnetic energy. For this purpose the winding 11 is connected at one of its ends via a diode 14 with the positive terminal of a storage battery 15, while its other end is connected via an interrupter switch 16 with the negative terminal of the battery via ground. The interrupter switch 16 is provided with a shunt capacitor 17 and is actuated in a well-known manner by a four-lobe cam 18 under the assumption that the particular ignition arrangement cooperates with a four-cylinder engine.

The other primary circuit connected with the other primary winding or portion thereof 12 includes in addition to the battery 15 a charging circuit 20 for charging a capacitor 21 and, for the capacitor discharge an connection with one end of the primary winding 12 via a second diode 22, and on the other side of the primary winding 12 a discharge control switch 23 which, when closed, completes the discharge circuit via ground and is also actuated by a four-lobe cam 24.

Both cams 18 and 24 are mounted on a shaft, not shown but represented by a broken line and assumed to be driven in the case of a four-stroke engine at the same speed as the control shaft thereof. The cams 18 and 24 are so arranged relative to each other that the discharge control switch 23 is closed when the interrupter switch 16 is opened, and vice versa. Details of the time relation between the operation of these two switches will be set forth further below.

The diodes 14 and 22 have the purpose of decoupling the two primary circuits in a well-known manner.

The secondary winding 10 is connected in conventional manner with a distributor 25 the contact arm whereof rotates also at the speed of the above mentioned control shaft and in this manner output or ignition impulses from the secondary winding 10 are applied via the distributor 25 to anyone of the spark plugs 26 of a four-stroke internal combustion engine, only one of the spark plugs being illustrated.

The operation of the above described arrangement is as follows. Whenever the interrupter 16 is in closed or conductive condition and the discharge control switch 23 is in open or non-conductive condition, current from the storage battery 15 flows via the diode 14 and through the primary winding 11 of the transformer whereby a magnetic field is produced in the transformer. Simultaneously the capacitor 21 is charged by the battery 15 and the charging circuit 20 while the discharge control switch 23 is still in open position. As the cam shaft continues its rotation the cam 18 opens the interrupter switch 16 so that the current flowing through the primary winding portion 11 is interrupted. Hereby the magnetic field of the winding 11 is changed so that a voltage is induced in the secondary winding 10 of the ignition transformer so that an igniting impulse is delivered to the distributor 25 and thereby to the spark plug 26.

Substantially simultaneously with the change of the interrupter switch 16 to non-conductive condition the discharge control switch 23 has been closed so that the capacitor 21 could discharge across the other primary winding portion 12 of the transformer. The resulting voltage pulse is transformed at a ratio predetermined by the ratio between the number of turns of the windings 12 and 10 also into an ignition pulse which is applied in the same manner as described above to the spark plug 26. The sum or combination of the two described

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impulses which produce the ignition of the fuel-air mixture is illustrated by FIG. 3.

It should be borne in mind that in order to obtain exactly an oscillogram as illustrated by FIG. 3 it is desirable that that portion of the ignition impulse which is due to the discharge of the capacitor occurs slightly ahead of the start of the impulse portion which is due to the release of the stored magnetic energy from the primary winding 11. Since in the case of an impulse caused by the release of the stored magnetic energy some time delay is unavoidable until the first secondary discharges start to appear, even an absolute time coincidence between the start of the two energy releases will still provide for the above mentioned desirable time relationship. On the other hand it would be very easy to so adjust the relative position of the cams 18 and 24 on their common shaft to establish the desired sequence in a mechanical way.

The embodiment according to FIG. 5 differs from the embodiment according to FIG. 4 first of all in that two separate ignition transformers 30, 31 and 32, 33 are provided, one for each primary circuit, respectively. Again the diodes 34 and 35 are provided for decoupling the two secondary circuit portions. As can be seen the two secondary windings 31 and 33 are both connected with the distributor 25. Otherwise the arrangement according to FIG. 5 contains the same elements as the embodiment according to FIG. 4 and also its operation is the same.

An ignition arrangement comprising separate ignition transformers instead of one common ignition transformer having only one secondary winding and one or two primary windings yields the advantage that the primary and secondary circuits of the ignition transformers can be adapted more freely and easily to the conditions prevailing in different types of internal combustion engines.

Instead of mechanical circuit interrupters and discharge control switches electronic switch means may be used as well in order to control the primary circuits of the invention arrangement. In this manner also other desired features can be accomplished easily. For instance one or the other of the two primary circuits may be switched on or off arbitrarily or automatically, or the above mentioned time relation between the first rise of the voltage derived from the capacitor discharge and the first rise of voltage derived from the interruption of the current flow through the primary winding can be accomplished even more precisely and easily than with mechanically operated switches.

FIG. 6 illustrates a further modification of the invention, characterized by one ignition transformer having only one primary winding and one secondary winding, combined with electronic control means.

The ignition transformer has a primary winding 40 and a secondary winding 41. The secondary winding 41 is connected as in the previous examples via a distributor 42 with spark plugs 43 of which only one is shown. The basic control of the ignition operation is carried out by an interrupter switch 44 arranged in the primary circuit of the ignition transformer and actuated periodically by a four-lobe cam 45 driven in the same manner as described above.

The capacitor type ignition portion of the arrangement comprises a storage capacitor 47 connected for the purpose of being charged with a storage battery 48 via a charging circuit 49 of conventional type. For the discharge the capacitor 47 is connected via a semiconductor gate 50 with the primary winding 40. The semiconductor gate 50 operates in such a manner that when the interrupter 44 is in conductive condition a discharge of the capacitor 47 is prevented, however when the interrupter 44 changes to non-conductive condition the gate 50 becomes conductive so that now the capacitor 47 is able to discharge via the primary 40 of the ignition transformer so that by the induced ignition impulse the con-

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nected spark plug 43 is energized. For controlling the semiconductor gate 50 a control circuit is provided which comprises an auxiliary transformer 51, 52 which has a secondary 52 connected in parallel with a resistor 53 and a capacitor 54. This parallel combination is connected with the discharge circuit as shown in FIG. 6. If now the interrupter switch 44 is moved to open position a capacitor 46 in the circuit of the primary winding 51 is charged across a resistor 46'. The voltage pulse occurring at such moment is transmitted via the transformer 51, 52 to the control electrode of the gate 50 whereby the latter is rendered conductive.

After in the above described manner the discharge of the capacitor 47 has produced an ignition impulse, the magnetic energy stored in the ignition transformer 40, 41 is released for producing the desired secondary discharges to be applied to the spark plugs.

For releasing the secondary discharges a transistor 56 is arranged in the circuit of the primary winding 40 of the ignition transformer 40, 41. This transistor 56 is controlled in the same manner as the gate 50 by the interrupter switch 44. For this purpose the base 57 of the transistor 56 is connected via a base resistor 61 with the interrupter 44, while the emitter 58 is connected with the positive terminal of the storage battery 48 and the collector 59 is connected via a resistor 62 with the primary winding 40. Between the base and the emitter of the transistor 56 a protective resistor 60 is arranged. A diode 64 in the collector connection serves to decouple the transistor circuit, on one hand, and the circuit of the capacitor 47, on the other hand.

The primary winding 40 of the ignition transformer is provided with a tap. As can be seen, a changeover switch 55 may be used for connecting the collector of the transistor 56 either directly with one end of the winding 40 or, in the other position of the switch 55, with the above mentioned tap. Hereby the transformation ratio in the ignition transformer 40, 41 can be increased and hereby the ignition potential can be increased which is obtained when the inductive circuit controlled by the transistor 56 is interrupted.

A switch 63 is provided between the transistor 56 and the storage battery 48. This switch may be operated arbitrarily or even automatically. It may be combined with the normal ignition switch of an automobile. When the switch 63 is in closed position and the interrupter 44 is in conductive condition a current flows from the battery 48 via switch 63, emitter and collector of the transistor 56 and via resistor 62 and diode 64 through the primary winding 40 and from there to ground. When the interrupter 44 opens the collector current of the transistor flowing through the winding 40 is interrupted so that hereby a voltage is induced in the secondary winding 41 which constitutes an ignition impulse for energizing the spark plugs 43. When the interrupter 44 is moved to non-conductive position the base 57 of the transistor 56 assumes via resistor 60 the same potential as the emitter so that the conductivity of the transistor is eliminated until the interrupter 44 returns to closed condition whereafter the whole cycle of operations may repeat.

The switch 63 may be also combined with the gas pedal so that the switch 63 is actuated only when the car is started or depending upon the position of the gas pedal. For instance if the car is to be started under unfavorable conditions like very low temperatures or with a weak fuel-air mixture, then it may be desirable to operate only with the capacitor type portion of the ignition arrangement because this type of operation is particularly effective under such conditions.

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

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as embodied in ignition arrangements for internal combustion engines including electric and magnetic energy storage means, 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, fairly 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 following claims.

What is claimed as new and desired to be secured by Letters Patent is:

1. Ignition arrangement for internal combustion engines, comprising, in combination, ignition transformer means having primary winding means and secondary winding means; first circuit means connected with at least a portion of said primary winding means and including capacitor means and capacitor charging means for storing electric energy in said capacitor means; second circuit means including a source of electric energy and connected also with at least a portion of said primary winding means for storing magnetic energy therein; ignition impulse output means connected with said secondary winding means of said ignition transformer means for delivering ignition impulses when such impulses are generated in said secondary winding means; and combined control means in both said first and second circuit means and including capacitor discharge control means for causing at the moments when delivery of ignition impulses are desired the release of said stored electric energy from said capacitor means and circuit interrupter means for causing substantially at said moments also the release of said stored magnetic energy from that portion of said primary winding means to which said second circuit means is connected in such a manner that by both said releases of stored energy inductively ignition impulses are generated in said secondary winding means.

2. Ignition arrangement for internal combustion engines, comprising, in combination, ignition transformer means having a first and a second primary winding means and one secondary winding means; first circuit means connected with said first primary winding means and including capacitor means and capacitor charging means for storing electric energy in said capacitor means; second circuit means including a source of electric energy and connected with said second primary winding means for storing magnetic energy therein; ignition impulse output means connected with said secondary winding means of said ignition transformer means for delivering ignition impulses when such impulses are generated in said secondary winding means; and combined control means in both said first and second circuit means and including capacitor discharge control means for causing at the moments when delivery of ignition impulses are desired the release of said stored electric energy from said capacitor means and circuit interrupter means for causing substantially at said moments also the release of said stored magnetic energy from said second primary winding means in such a manner that by both said releases of stored energy inductively ignition impulses are generated in said secondary winding means.

3. Ignition arrangement for internal combustion engines, comprising, in combination, ignition transformer means having one primary winding means and one secondary winding means; first circuit means connected with said one primary winding means and including capacitor means and capacitor charging means for storing electric energy in said capacitor means; second circuit means including a source of electric energy and connected also with said one primary winding means for storing magnetic

energy therein; ignition impulse output means connected with said secondary winding means of said ignition transformer means for delivering ignition impulses when such impulses are generated in said secondary winding means; and combined control means in both said first and second circuit means and including capacitor discharge control means for causing at the moments when delivery of ignition impulses are desired the release of said stored electric energy from said capacitor means and circuit interrupter means for causing substantially at said moments also the release of said stored magnetic energy from that portion of said primary winding means to which said second circuit means is connected in such a manner that by both said releases of stored energy inductively ignition impulses are generated in said secondary winding means.

4. Ignition arrangement for internal combustion engines, comprising, in combination, ignition transformer means having one primary winding means having at least one tap and one secondary winding means; first circuit means connected with said one primary winding means and including capacitor means and capacitor charging means for storing electric energy in said capacitor means; second circuit means including a source of electric energy and connected also with said one primary winding means for storing magnetic energy therein and further including control means for connecting when desired said source with only a portion of said primary winding means through said tap thereof; ignition impulse output means connected with said secondary winding means of said ignition transformer means for delivering ignition impulses when said impulses are generated in said secondary winding means; and combined control means in both said first and second circuit means for causing at the moments when delivery of ignition impulses are desired the release of said stored electric energy from said capacitor means and of said stored magnetic energy through said secondary winding means so as to generate therein ignition impulses.

5. Ignition arrangement for internal combustion engines, comprising, in combination, a first and a second ignition transformer means each having primary winding means and secondary winding means; first circuit means connected with said primary winding means of said first transformer means and including capacitor means and capacitor charging means for storing electric energy in said capacitor means; second circuit means including a source of electric energy and connected with said primary winding means of said second transformer means for storing magnetic energy therein; ignition impulse output means connected with said secondary winding means of both said ignition transformer means for delivering ignition impulses when such impulses are generated in said secondary winding means; and combined control means in both first and second circuit means for causing at the moments when delivery of ignition impulses are desired the release of said stored electric energy from said capacitor means and of said stored magnetic energy through said secondary winding means so as to generate therein ignition impulses.

6. Ignition arrangement for internal combustion engines, comprising, in combination, ignition transformer means having primary winding means and secondary winding means; first circuit means connected with at least a portion of said primary winding means and including capacitor means and capacitor charging means for storing electric energy in said capacitor means; second circuit means including a source of electric energy and connected also with at least a portion of said primary winding means for storing magnetic energy therein, said first and second circuit means including means for decoupling said two circuit means; ignition impulse output means connected with said secondary winding means of said ignition transformer means for delivering ignition impulses when such impulses are generated in said sec-

ondary winding means; and combined control means in both said first and second circuit means and including capacitor discharge control means for causing at the moments when delivery of ignition impulses are desired the release of said stored electric energy from said capacitor means and circuit interrupter means for causing substantially at said moments also the release of said stored magnetic energy from that portion of said primary winding means to which said second circuit means is connected in such a manner that by both said releases of stored energy inductively ignition impulses are generated in said secondary winding means.

7. An arrangement as claimed in claim 1, wherein said combined control means include in said first circuit means capacitor discharge control means periodically changeable between non-conductive and conductive condition, and in said second circuit means circuit interrupter means periodically changeable between conductive and non-conductive condition, said discharge control means and said interrupter means being operatively connected in such a manner that said discharge control means is changed to conductive condition substantially simultaneously with said interrupter means being changed to non-conductive condition.

8. An arrangement as claimed in claim 2, wherein said capacitor discharge control means are periodically changeable between non-conductive and conductive condition, and said interrupter means are periodically changeable between conductive and non-conductive condition, said discharge control means and said interrupter means being operatively connected in such a manner that said discharge control means is changed to conductive condition substantially simultaneously with said interrupter means being changed to non-conductive condition.

9. An arrangement as claimed in claim 4, wherein said combined control means include in said first circuit means capacitor discharge control means periodically changeable between non-conductive and conductive condition, and in said second circuit means circuit interrupter means periodically changeable between conductive and non-conductive condition, said discharge control means and said interrupter means being operatively connected in such a manner that said discharge control means is changed to conductive condition substantially simultaneously with said interrupter means being changed to non-conductive condition.

10. An arrangement as claimed in claim 5, wherein said combined control means include in said first circuit means capacitor discharge control means periodically changeable between non-conductive and conductive condition, and in said second circuit means circuit interrupter means periodically changeable between conductive and non-conductive condition, said discharge control means and said interrupter means being operatively connected in such a manner that said discharge control means is changed to conductive condition substantially simultaneously with said interrupter means being changed to non-conductive condition.

11. An arrangement as claimed in claim 1, wherein said combined control means include in said first circuit means capacitor discharge control means comprising electronic control elements periodically changeable between non-conductive and conductive condition, and in said second circuit means circuit interrupter means periodically changeable between conductive and non-conductive condition, said discharge control means and said interrupter means comprising electronic control elements operatively connected in such a manner that said discharge control means is changed to conductive condition substantially simultaneously with said interrupter means being changed to non-conductive condition.

12. An arrangement as claimed in claim 7, wherein said combined control means include means for causing the first rise of that portion of said ignition impulses which is generated by the release of energy stored in said capaci-

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tor means to occur slightly ahead of the first rise of that portion of the particular impulses which is generated by the release of said stored magnetic energy.

13. An arrangement as claimed in claim 8, wherein said combined control means include means for causing the first rise of that portion of said ignition impulses which is generated by the release of energy stored in said capacitor means to occur slightly ahead of the first rise of that portion of the particular impulses which is generated by the release of said stored magnetic energy.

14. An arrangement as claimed in claim 9, wherein said combined control means include means for causing the first rise of that portion of said ignition impulses which is generated by the release of energy stored in said capacitor means to occur slightly ahead of the first rise of that portion of the particular impulses which is generated by the release of said stored magnetic energy.

15. An arrangement as claimed in claim 10, wherein said combined control means include means for causing the first rise of that portion of said ignition impulses which is generated by the release of energy stored in said capacitor means to occur slightly ahead of the first rise of that portion of the particular impulses which is generated by the release of said stored magnetic energy.

16. An arrangement as claimed in claim 11, wherein said combined control means include means for causing the first rise of that portion of said ignition impulses which is generated by the release of energy stored in said capacitor means to occur slightly ahead of the first

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rise of that portion of the particular impulses which is generated by the release of said stored magnetic energy.

17. An arrangement as claimed in claim 1, wherein at least one of said first and second circuit means includes switch means for rendering the respective circuit means operative and inoperative as may be desired.

18. An arrangement as claimed in claim 2, wherein at least one of said first and second circuit means includes switch means for rendering the respective circuit means operative and inoperative as may be desired.

19. An arrangement as claimed in claim 4, wherein at least one of said first and second circuit means includes switch means for rendering the respective circuit means operative and inoperative as may be desired.

20. An arrangement as claimed in claim 5, wherein at least one of said first and second circuit means includes switch means for rendering the respective circuit means operative and inoperative as may be desired.

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