The present invention concerns an ignition circuit arrangement for internal combustion engines, and more particularly that type of such arrangements in which a storage capacitor is used that is either operatively connected directly with the spark plugs of the engine via switch means including a distributor or is inductively coupled with the spark plugs via said switch means by interposition of an ignition transformer.

It is well known that such capacitor-type ignition arrangements display a high ignition power sufficient for producing sparks at the spark plugs even if the spark plug electrodes are more or less contaminated or covered with carbon deposits. However, if the fuel-air mixture furnished to the engine is inhomogeneous or poor, e.g. at intermediate positions of the gas pedal, then the known capacitor-type ignition arrangements are not always capable of igniting such mixtures without occasional skipping.

It is therefore one object of this invention to improve the capacitor-type circuit arrangements in such a manner that the above mentioned disadvantage is safely avoided.

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

With above objects in view the invention includes in a capacitive circuit arrangement for internal combustion engines, including an auxiliary spark plug and switch means for periodically closing an operative circuit for the spark plug, in combination, main storage capacitor means operatively connected with said spark plug subject to control by said switch means; at least one auxiliary storage capacitor means connected in parallel with said main storage capacitor means; choke coil means connected between said main and auxiliary storage capacitor means; and means for charging said main and auxiliary storage capacitor means to a predetermined potential, whereby every time when by said switch means an operative circuit is established for said spark plug, first said main storage capacitor means is discharged therethrough and thereafter said auxiliary storage capacitor means is discharged therethrough with a delay depending upon said choke coil means.

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 drawing, in which:

FIG. 1 is a schematic circuit diagram illustrating a capacitive ignition circuit arrangement according to the invention;

FIG. 2 is a graph illustrating the variation with time of the voltage at a spark plug electrode during one ignition sequence produced by the arrangement according to the invention;

FIG. 3 is a schematic circuit diagram of a modification of the arrangement of FIG. 1; and

FIG. 4 is a schematic circuit diagram illustrating another modification of the arrangement according to FIG. 1.

The ignition circuit arrangement according to FIG. 1 comprises a main storage capacitor 10 of e.g. 5 µF, which is continuously subject to being charged by a charging circuit 11 to a potential of 300 to 500 volts. The charging circuit 11 is supplied by a storage battery 12. At the moment of ignition the discharge voltage of the capacitor 10 is increased by an ignition transformer 13 to about 15,000 to 20,000 volts. For controlling and timing the ignition a conventional control switch 14 is connected in circuit with the main capacitor 10 and the primary winding of the transformer 15 and is periodically moved between open and closed positions in a conventional manner by the action of a four-lobe cam 16 rotating jointly with the wiper arm 17 of the conventional distributor. In the illustrated position of the switch 14 the circuit between the capacitor 10 and ground is interrupted and the capacitor 10 is being charged. When the switch 14 is moved to closed position then the main capacitor 10 is promptly discharged via the primary of the transformer 13 so that ignition energy is furnished by the secondary of the transformer to one of the four spark plugs 16 depending upon which of them is at the given moment connected by the distributor 17 with the secondary of the transformer 13.

However, in addition to the main storage capacitor 10 two more auxiliary storage capacitors 18 of e.g. 5 µF each are connected in parallel with the main capacitor 10 on the primary side of the transformer 13. Between the main capacitor 10 and the first of the auxiliary capacitors 18 and also between the adjacent auxiliary capacitors 18, respectively, choke coils 19 having an inductivity of e.g. 2 to 3 mh. are arranged as shown in FIG. 1. Thus, the capacitors 18 and the coils 19 constitute a delay line by which after the discharge of the main capacitor 10 additional discharge and consequently voltage pulses 16 are produced. By means of these subsequent or secondary discharges and resulting sparks also those types of fuel-air mixtures are ignited which are inhomogeneous or poorly mixed as may occur when the gas pedal is in an intermediate position during operation of the engine.

The oscillogram according to FIG. 2 illustrates how the ignition voltage $U_0$ varies with time during one ignition phase produced by the arrangement according to the invention. The first voltage peak corresponds to the discharge of the main storage capacitor 10, while the following voltage peaks correspond to the successive following discharges of the auxiliary storage capacitors 18. The delays between the first and second voltage peak as well as between the second and third voltage peak depends on the action of the choke coils 19. The dotted line appearing at the end of the first voltage peak illustrates how the voltage would drop off if the auxiliary capacitors 18 and the choke coils 19 would not exist in the arrangement.

Similar effects can be obtained by using the modified arrangement according to FIG. 3. In this case only one capacitor namely the main storage capacitor 21 with a capacity of e.g. 0.2 µF. is arranged on the primary side of the ignition transformer 28. For controlling and timing the ignition a control switch 22 actuated by a four-lobe cam 22 in cooperation with a conventional ignition distributor 23 is provided in a conventional manner. The distributor 23 is connected with four spark plugs 24. A delay line composed of three auxiliary storage capacitors 26, 26 and 27 having each a capacity of e.g. 0.1 µF. and three choke coils 28, 29, 30 having an inductivity of e.g. 2 mh. are again connected in parallel with
3,234,430 the main capacitor 21 but on the secondary side of the transformer 20 and also in circuit with the distributor 23. In this case the secondary is conductively connected with the primary winding of the transformer 20. Thus the main capacitor 21 as well as the auxiliary capacitors 25-27 can be charged simultaneously by a conventional charging circuit 31 to a charge potential of e.g. 2,000 to 3,000 volts. The operation of this arrangement is quite analogous to the one described above. When the switch 22 is moved to another position so as to cause a discharge of the main capacitor 21, a sequence of secondary discharges of the auxiliary capacitors 25-27 in succession follows automatically as the area between the spark plug electrodes has been ionized by the first spark resulting from the first discharge of the main capacitor 21.

Finally, FIG. 4 illustrates another modification of the invention. In this case an arrangement is shown which does not include an ignition transformer. Thus, in this arrangement a main storage capacitor 40 is directly connected to the distributor 48 which actuates in the conventional manner the spark plugs 49. The main capacitor 40 may have a capacity of .1 µf. Again a delay line is provided and comprises three auxiliary capacitors 44-46 together with choke coils 41-43 arranged in parallel with the main storage capacitor 40 as shown in FIG. 4. The choke coils 41-43 may be each an inductivity of three to five mb, and the auxiliary capacitors may have a capacitance of 0.01 µf.

For charging the capacitors 40 and 44-46 a charging circuit 47 is provided which is capable of charging the capacitors to a potential of 3,000 to 5,000 volts. The distributor 48 may be of conventional type which is suitable for handling the above-mentioned high voltages. As the wiper of the distributor 48 rotates discharge of the capacitors 40 and 44-46 in succession is initiated whenever the wiper arm of the distributor is in contact with one of the stationary contacts connected with the various spark plugs 49, respectively.

It should be noted that if the delay lines would be chosen so as to be composed of a substantially greater number of capacitors and choke coils, then separate voltage pulses will not appear in succession at the spark plug electrodes but rather a voltage pulse of extended duration.

It has been found by external experimentation that by using either one of the embodiments described or having the characteristic features of the invention a very substantial improvement of the ignition process over the performance of the conventional capacitive ignition circuits having only one storage capacitor has been established. In this manner, due to the action of the delay line mentioned above particularly inhomogeneous fuel-air mixture may be used without the occurrence of skipping of the ignition.

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 a capacitive ignition circuit arrangement for internal combustion engines and differing from the types described above.

While the invention has been illustrated and described as embodied in a capacitive ignition circuit arrangement for internal combustion engines including a plurality of storage capacitor 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, fail to 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 and desired to be secured by Letters Patent is:

1. In a capacitive ignition circuit arrangement for internal combustion engines, including at least one spark plug and switch means for periodically closing an operative circuit for the spark plugs, in combination, main storage capacitor means operatively connected with said spark plug subject to control by said switch means; at least one independent auxiliary storage capacitor means connected in parallel with said main storage capacitor means; choke coil means connected between said main and auxiliary storage capacitor means for delaying discharge of said auxiliary storage capacitor means; and means for charging said main and auxiliary storage capacitor means to a predetermined potential, whereby each time said switch means establishes an operative circuit for said spark plug, said main storage capacitor means first discharges through said operative circuit and thereby said auxiliary storage capacitor means discharges independently and separately from said main and auxiliary storage capacitor means determined by said choke coil means.

2. In a capacitive ignition circuit arrangement for internal combustion engines, including a plurality of spark plugs and switch means for periodically closing an operative circuit for the spark plugs, in combination, main storage capacitor means operatively connected with said spark plugs, subject to control by said switch means; at least one independent auxiliary storage capacitor means connected in parallel with said main storage capacitor means; choke coil means connected between said main and auxiliary storage capacitor means for delaying discharge of said auxiliary storage capacitor means; and means for charging said main and auxiliary storage capacitor means to a predetermined potential, whereby each time said switch means establishes an operative circuit for any one of said spark plugs, said main storage capacitor means first discharges through said operative circuit and thereby said auxiliary storage capacitor means discharges independently and separately from said main and auxiliary storage capacitor means determined by said choke coil means.

3. In a capacitive ignition circuit arrangement for internal combustion engines, including a plurality of spark plugs and switch means for periodically closing an operative circuit for the spark plugs, in combination, main storage capacitor means induectively coupled with said spark plugs subject to control by said switch means; at least one independent auxiliary storage capacitor means connected in parallel with said storage capacitor means; choke coil means connected between said main and auxiliary storage capacitor means for delaying discharge of said auxiliary storage capacitor means; and means for charging said main and auxiliary storage capacitor means to a predetermined potential, whereby each time said switch means establishes an operative circuit for any one of said spark plugs, said main storage capacitor means first discharges through said operative circuit and thereby said auxiliary storage capacitor means discharges independently and separately from said main storage capacitor means determined by said choke coil means.

4. In a capacitive ignition circuit arrangement for internal combustion engines, including a plurality of spark plugs and switch means for periodically closing an operative circuit for the spark plugs, in combination, main storage capacitor means operatively connected with said spark plugs subject to control by said switch means; a plurality of independent auxiliary storage capacitor means connected in parallel with said main storage capacitor means; a plurality of choke coil means connected between said main storage capacitor means and one of said auxili-
5. In a capacitive ignition circuit arrangement for internal combustion engines, including a plurality of spark plugs and switch means for periodically closing an operative circuit for the spark plugs, in combination, main storage capacitor means inductively coupled with said spark plugs subject to control by said switch means; a plurality of independent auxiliary storage capacitor means connected in parallel with said main storage capacitor means; a plurality of choke coil means connected between said main storage capacitor means and one of said auxiliary storage capacitor means, and between adjacent ones of said auxiliary storage capacitor means, respectively for delaying discharge of each of said auxiliary storage capacitor means; and means for charging said main and auxiliary storage capacitor means to a predetermined potential, whereby each time said switch means establishes an operative circuit for any one of said spark plugs, said main storage capacitor means first discharges through said operative circuit and thereafter each of said auxiliary storage capacitor means discharges independently and separately from said main storage capacitor means and from the others of said auxiliary storage capacitor means through said operative circuit at a time after the discharge of said main storage capacitor means determined by the corresponding choke coil means, said auxiliary storage capacitor means discharging one after the other in succession.

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