May 22, 1945. A. A. KASARJIAN 2,376,362

IGNITION SYSTEM

Filed April 2, 1942

Fig. 1.

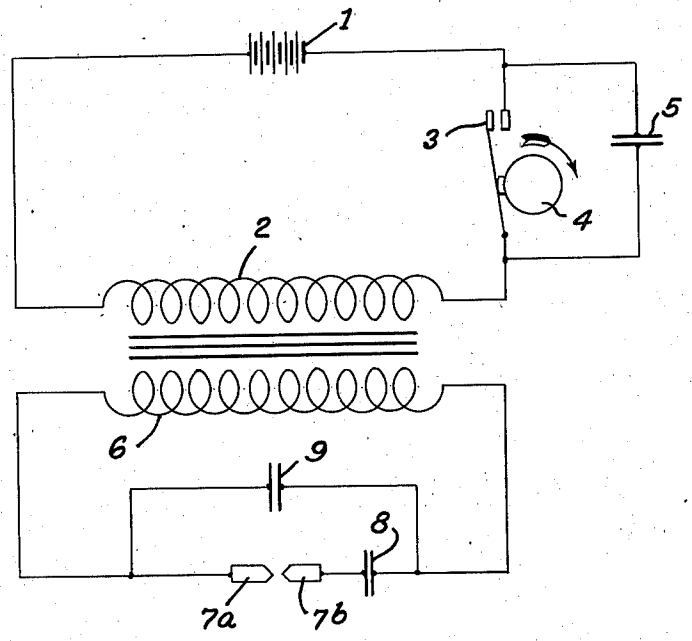
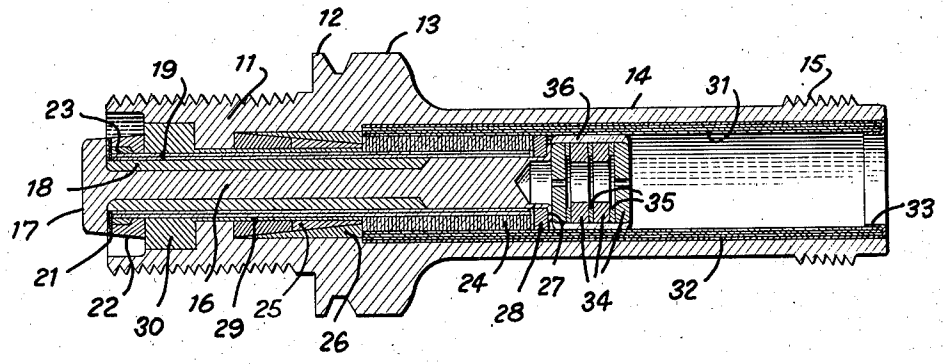


Fig. 2.



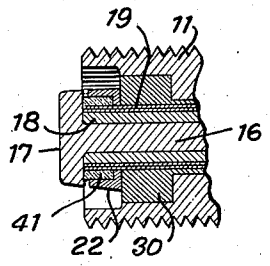


Fig. 3.

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IGNITION SYSTEM

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6 Claims. (Cl. 313—85)

This invention relates to ignition systems for internal combustion engines and to spark plugs adapted for use in such systems.

In the usual ignition systems for internal combustion engines, a spark plug is commonly employed having spaced electrodes forming a gap across which a spark is caused to jump in order to ignite the gaseous charge in the cylinder. In theory, it is necessary to provide a sufficiently high voltage to ionize the gases at the gap. When such ionization occurs, there is a discharge of electrical energy across the gap to form the spark.

In practice, such ignition systems include a source of electrical energy such as a magneto or battery, a primary and secondary coil, and some form of circuit breaking device for interrupting the flow of current from the source to the primary. When the supply of current to the primary is interrupted, the voltage in the secondary increases until it reaches a point sufficiently high to ionize the gases at the gap, and an oscillating, high voltage capacity discharge occurs which quickly discharges some of the accumulated electrical energy and greatly reduces the voltage of the remainder. However, since the gap has been ionized, the lower voltage is still sufficient to bridge the gap and a continuous current arc is established between the electrodes. This arc continues until the accumulated electrical energy is spent. In the art, the high voltage capacity discharge has been referred to as the capacity component of the spark, and the subsequent low voltage current discharge has been referred to as the inductance component or "tail" of the spark. It has been generally recognized that the inductance component is of no material value for ignition purposes, and is, in fact, undesirable because it causes erosion of the electrodes.

Heretofore it has been proposed to place a condenser of relatively small capacity in series with the spark plug in order to eliminate the inductance component, and to cause the accumulated energy to be discharged in the form of a series of capacity components. Such condensers have been referred to in the art as "converters," "current transformers," "interrupters" and the like. Such condensers serve to arrest the flow of current at the gap immediately after the initial capacity discharge has taken place due to the reduction in voltage caused by such discharge. Thereafter, the voltage of the remaining energy increases until a second capacity discharge takes place, and so on until the energy is spent in the form of a series of such capacity discharged.

While the theory underlying the use of such condensers apeared correct, it was noted that the improvement in the performance of ignition systems in which they were incorporated was negligible. As a result, their use has been generally discontinued.

I have discovered that one reason for the lack of improvement lay in the fact that the capacity of the usual ignition systems with which such condensers were used was relatively small. Consequently, the intensity of the individual capacity discharges which took place was relatively weak. It is an object of the present invention, therefore, to employ such a condenser in an ignition system of relatively large capacity, in order to provide a series of capacity discharges of high intensity.

It is a further object of the invention to provide a spark plug particularly adapted for use in such a system.

Other objects and advantages of the invention will appear hereinafter.

A preferred embodiment of the invention selected for purposes of illustration is shown in the accompanying drawing, in which,

Figure 1 is a diagram of a circuit embodying the ignition system of the present invention, and

Figure 2 is a vertical section through a spark plug particularly adapted for use in such a system.

Figure 3 is a similar vertical section of the lower end of a plug showing a modified type of insulation.

According to the present invention I propose to increase the capacity of the ignition system by providing an additional condenser of relatively large capacity, which said condenser is connected in parallel with the spark plug. This is illustrated diagrammatically in Figure 1, in which 1 is a source of electrical energy and 2 is a primary coil connected thereto, the primary circuit including any suitable means for interrupting the flow of current to the primary coil, such as a circuit breaker 3 operated by a cam 4, the usual condenser 5 being connected in parallel with the breaker. The secondary circuit includes the secondary coil 6 and the spaced electrodes 7*a* and 7*b* of the spark plug. Connected in series with the spark plug is a condenser 8 of relatively small capacity which has heretofore been referred to as a "converter," and connected in parallel with the spark plug and across the spark plug and the condenser 8 is a condenser 9 of relatively large capacity. For example, the condenser 8 may have a capacity of about 4 mmf. and the condenser 9 may have a capacity of about 200 mmf. for good results. In this connection, it may be noted that

in some ignition systems, and particularly in ignition systems adapted for use in aircraft engines, in order to avoid radio interference, it is now the practice to shield the high tension cables leading from the secondary to the spark plugs by surrounding said cables with a metallic jacket. In fact, spark plugs adapted for use in such shielded systems are themselves shielded by the provision of an outer metallic jacket. It will, of course, be obvious that such shielding jackets serve as condensers of relatively large capacity, for such jackets as used in shielded systems ordinarily have a capacity in excess of 150 mmf. Since such shielding jackets are grounded, they are connected to the ignition system in parallel with the spark plug in the manner shown in Figure 1. Thus in shielded systems such shielding jackets serve admirably as the additional condenser 9. In unshielded systems, however, a separate condenser must be provided, and connected in parallel as shown in Figure 1.

The system described is particularly well adapted for use in aircraft engines due to the exacting requirements imposed by the nature of such engines, i. e., extreme high compressions, high temperatures, high speed, and the requirement for reliable performance and long life of the ignition system and of the spark plugs employed in such engines. Because of the intensity of the spark produced by the above described system, I have found it possible to safely reduce the size of the spark gap of the usual spark plugs used in such engines, and thereby secure important advantages of increased reliability and increased life. Heretofore it has been the accepted view that the spark gap in spark plugs for aircraft engines should not be less than .012", because it was found by experience that a smaller gap would quickly foul by the accumulation of carbon, particularly when the engine was idling or running at low speed. Such fouling, resulting in parasitic losses at the gap, soon prevented the plug from firing. By causing sparks to be formed as a series of capacity discharges of high intensity, in accordance with my invention, I find that such sparks will burn off any accumulations of carbon which may tend to form on the electrodes, and that it is possible, therefore, to reduce the gap to .010" or less. For example, I have reduced the gap to as little as .003" with successful results, but mechanical limitations of design for commercial manufacture make this difficult in ordinary production. Therefore, for ordinary commercial use, I provide a gap of approximately .007" and find that this gives excellent results, and that a plug so adjusted and used in such a system will continue to fire properly even when the engine is idled over a period of several hours.

I have also found it possible to utilize a new type of spark plug to advantage in such systems, such plug being illustrated in Figure 2. The said plug is of the shielded type, adapted for connection to a shielded cable performing the functions of the condenser 9 of the diagram of Figure 1, and said plug includes within its structure a condenser or "converter" performing the functions of the condenser 8 of Figure 1.

The said plug comprises an outer shell 11 having its lower portion threaded to screw into a cylinder head of an engine. Above the threaded portion is an enlarged portion having a flange 12, adapted to seat against a gasket, and a hexagonal portion 13 adapted to fit a wrench. Above the enlarged portion is a tubular portion 14 constituting the shielding of the plug, this tubular portion being provided with a thread 15 adapted to receive a threaded coupling connecting the plug to the shielding of the cable.

Extending axially of the shell 11 is a central spindle 16 terminating at its lower end in a flanged head 17 constituting one of the electrodes of the plug. The said spindle is preferably made of alloy steel and along a portion of its length is surrounded by a copper sleeve 18 adapted to conduct heat rapidly away from the flanged head 17.

The spindle is separated from the shell 11 by suitable insulation, comprising preferably a wrapping of cigarette mica 19 extending substantially from the upper end of the spindle to the lower end. At the extreme lower end of the spindle and lying flush with the upper surface of the flanged head 17 is an annular disk 21 of insulating material, preferably mica washers, which spaces the head from the annular ring 22 which constitutes the other electrode. The thickness of the disk 21 determines the gap between the electrodes, which, as previously stated is preferably less than .010". The inside lower corner of the ring 22 is cut away as shown to provide an annular space for the reception of refractory ceramic insulating material 23 in plastic form to prevent parasitic losses as described in my prior Patent No. 1,958,580, dated May 15, 1934.

Additional insulation is provided at the upper end of the spindle, preferably in the form of a stack of mica washers 24 surrounding the cigarette mica. The lower end of the stack rests on the upper ends of the conical sealing members 25 and 26 and the upper end of the stack is held in place by the flanged end 27 of the spindle, a steel ring 28 being interposed therebetween. The inner wall of the lower end of the shell 11 is lined with copper 29, the lower end of said copper lining comprising a relatively massive annular flange 30 adapted to contact the upper surface of the ring 22 as shown, to rapidly remove heat from the electrode ring 22. The provision of the copper sleeve 18 and the lining 29 and flange 30 provide very rapid cooling of the electrodes. This is a feature of great advantage in preventing preignition, but can only be used to advantage in a plug of this type in an ignition system as above described. In an ordinary ignition system the danger of fouling would be so great as to outweigh the advantage of rapid cooling.

Additional insulation is also provided at the upper end of the plug within the tubular portion 14. This is in the form of cigarette mica 31 extending from the upper end of the tubular portion 14 to the lower end of the stack of mica washers 24. The said cigarette mica is preferably contained in a thin brass tube 32 having its upper end turned over as shown at 33 to hold the mica in place.

Carried within the tube 31, 32 and in contact with the end of the spindle 16 is the condenser or "converter" previously referred to, and corresponding to the condenser 8 of Figure 1. As shown, said condenser comprises a series of metal washers 34 spaced by mica washers 35, said metal washers and mica washers being surrounded and encased in a wall of any suitable insulating material such as ceramic material 36 so that the condenser may be handled as a unit and easily replaced if necessary. The said condenser is held in contact with the end of the spindle by the usual spring fitting used to connect the plug to the cable.

In the modified form of plug shown in Figure 3, the mica washers 21 have been omitted and an

annular sleeve 41 of suitable refractory ceramic material in solid form is seated in the electrode ring 22, the lower end of said sleeve engaging the flanged head 17 as shown. In this case the height of the sleeve determines the gap between the electrodes, which, as previously stated, is less than .010". The said sleeve may also be coated with refractory ceramic material in plastic form to prevent parasitic losses as previously described.

It will be understood that the invention may be variously modified and embodied within the scope of the subjoined claims.

I claim as my invention:

1. In an ignition system for internal combustion engines, a secondary circuit including a spark plug, a secondary coil, a condenser of relatively small capacity connected in series with said spark plug, and a condenser of relatively large capacity connected across said spark plug and said condenser of relatively small capacity.

2. In an ignition system for internal combustion engines, a secondary circuit including a spark plug, a secondary coil, a condenser of relatively small capacity connected in series with said spark plug, a cable connecting said spark plug and said secondary coil, and a metallic shielding surrounding said cable, said metallic shielding constituting a condenser of relatively large capacity connected across said spark plug and said condenser of relatively small capacity.

3. In an ignition system for internal combustion engines, a secondary circuit including a spark plug, a secondary coil, a condenser of relatively small capacity connected in series with said spark plug, and a condenser of relatively large capacity connected across said spark plug and said condenser of relatively small capacity, said spark plug having electrodes spaced to provide a gap less than .010".

4. In an ignition system for internal combustion engines, a secondary circuit including a spark plug, a secondary coil, a condenser of relatively small capacity connected in series with said spark plug, and a condenser of relatively large capacity connected across said spark plug and said condenser of relatively small capacity, said spark plug having electrodes spaced to provide a gap of approximately .007".

5. In an ignition system for internal combustion engines, a secondary circuit including a spark plug, a secondary coil, a condenser of relatively small capacity connected in series with said spark plug, a cable connecting said spark plug and said secondary coil, and a metallic shielding surrounding said cable, said metallic shielding constituting a condenser of relatively large capacity connected across said spark plug and said condenser of relatively small capacity, said spark plug having electrodes spaced to provide a gap less than .010".

6. In an ignition system for internal combustion engines, a secondary circuit including a spark plug, a secondary coil, a condenser of relatively small capacity connected in series with said spark plug, a cable connecting said spark plug and said secondary coil, and a metallic shielding surrounding said cable, said metallic shielding constituting a condenser of relatively large capacity connected across said spark plug and said condenser of relatively small capacity, said spark plug having electrodes spaced to provide a gap of approximately .007".

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