

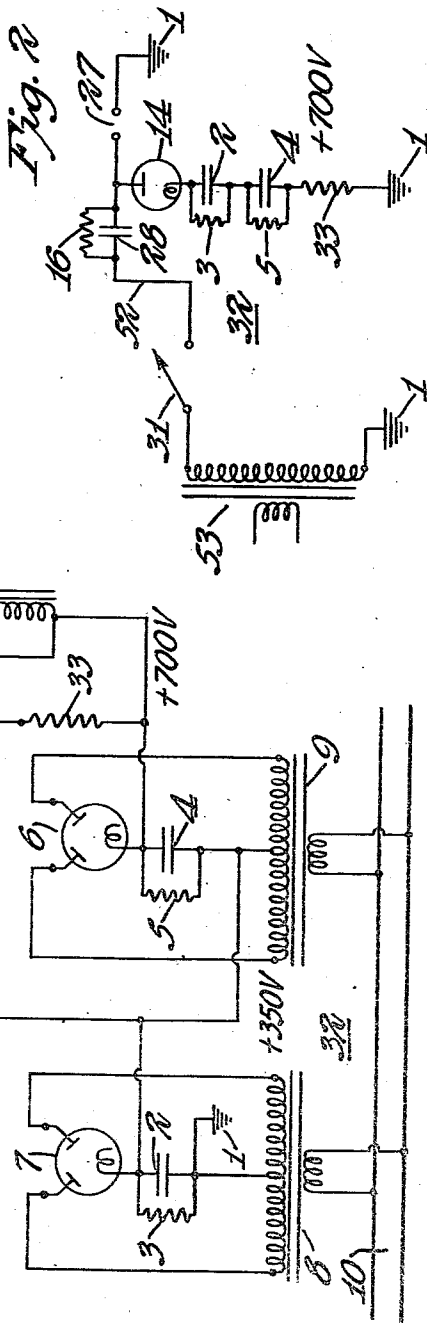
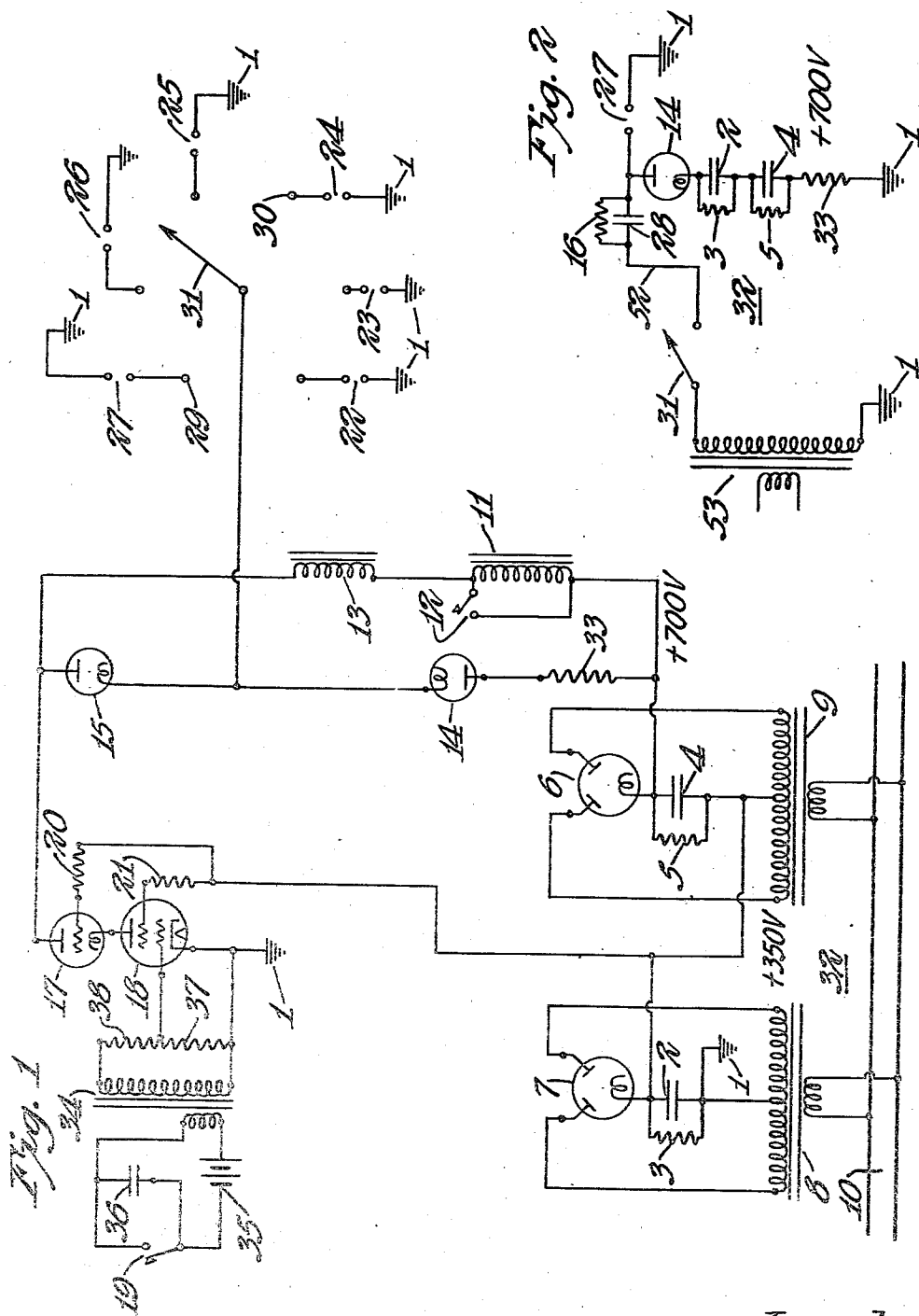
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ELECTRONIC IGNITION SYSTEM

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ELECTRONIC IGNITION SYSTEM

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This invention relates to ignition systems and more particularly to "booster" spark producing means.

In ignition in the cylinder of an internal combustion engine, two problems present themselves. 1. The release of electrons from the cathode terminal of a spark gap. 2. The vaporization of molecules of gasoline from the liquid spray to build up the required vapor pressure to permit ignition.

The reactions involved in both of these problems are Einstein's quantum reactions. 1. The release of an electron from a tungsten cathode requires a quantum of 4.5 electron volts, the energy of a photon of .28 mu wavelength. 2. The vaporization of a molecule of gasoline requires a quantum of .4 electron volts, the energy of a photon of 3 mu wavelength. Both of these problems are extremely aggravated by the low temperatures of cold weather. The radiation of a black body at thirty degrees below zero contains few photons of either of these wavelengths. At low temperatures electrons are not readily released from a metal, such as a cathode tungsten spark gap terminal, and the number of free electrons in the vicinity of the cathode terminal is very much reduced. It therefore requires a higher anode terminal voltage to give the necessary acceleration to the electrons in the gap to release a sufficient number of positive ions in said gap and to accelerate said ions to said cathode with sufficient velocity to release the necessary large number of electrons to produce a good spark. The problem of releasing electrons from the cathode terminal is further aggravated by the fact that the cathode is usually covered with a thick carbonized layer which has a higher work function than the metal from which the cathode is made. The cathode is also usually covered with a congealed insulating coating of cylinder oil. It is an object of this invention to produce a voltage sufficiently high to break through said insulating coating of oil, extract the electrons from the cathode, and to follow this break down voltage with a discharge current sufficient to melt said oil coating over a large portion of said cathode to render subsequent sparking across said gap more easy.

Another object is to illustrate how the anode of a spark gap may be maintained at a high positive D. C. potential for a period of time before breakdown to evaporize ice and short circuiting detrimental effects for said gap. Another object is to illustrate a resistance shunted by a con-

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denser for superimposing a breakdown high voltage on said D. C. potential.

The energy of a spark is $\frac{1}{2}LI^2$. At high speeds the L must not be too large or the current will not have time to build up through the inductance to produce a spark. For starting, however, where the speed of rotation of the motor is very slow, it is desirable to have the L as large as practicable in order to get as much energy as possible into the spark. It is an object of this invention to illustrate an auxiliary inductance coil and means for short circuiting said coil except for starting.

The second above mentioned problem, namely, the building up of required pressures of gasoline, which is taken into the cylinder in the form of liquid spray suspended in the intake air, is readily solved at ordinary temperatures by the heat of compression in said cylinder. However, at low temperatures, this heat of compression is not sufficient to heat the air and to build up the required vapor pressure in the cylinder, and ignition is therefore impossible, even though, as is usual practice, the motor may be fully "choked." This "choking" results in an undue waste of gasoline, and it is one of the objects of this invention to eliminate this waste.

Sir Humphry Davy early in the nineteenth century discovered that required vapor pressures were necessary to produce ignition between a gas and air. He found that more than six and less than fourteenth volumes of air would explode with one volume of methane when ignited, but that outside of those limits ignition would not readily occur.

To produce heat to create the required vapor pressures in the vicinity of the spark gap in cold weather, various "booster" spark systems have been devised. These systems usually take the form of means for interrupting a low voltage ignition coil primary current several times during the period that the distributor brush is making contact with each spark plug in order to produce several sparks at the spark gap instead of just one and thereby multiply the spark heating effect by the number of said sparks. The heat produced at the spark gap by such systems is very small, since, while .03 joules produces a good spark most of the energy is not dissipated at the spark gap but in the resistance of the secondary of the ignition coil. Furthermore, such systems must be operated on a retarded spark in order to prevent back fire. With a retarded spark the heat of compression which may have been considerable at top dead center has been dissipated

by the expansion of the air in the cylinder, with the resultant lowering of vapor pressure of gasoline in the cylinder. Even though ignition takes place with such a retarded spark, the power stroke is usually not sufficient to turn the crank shaft over several times, and the engine does not start.

It is an object of this invention to produce a large electrical discharge at the spark gap, thereby building up the required ignition vapor pressure of gasoline in the vicinity of said gap, even in extremely cold weather.

Another object is to produce a high voltage pulse to break down a spark gap and by a shunt low impedance path to pass a large current through said spark gap to produce a large dissipation of energy at said gap. Another object is to illustrate a means for breaking down a spark gap, and by a unidirectionally conductive gas discharge device passing a large current through said broken down gap.

The voltage of an automobile battery falls considerably in cold weather, when the starter turns the engine over. With a battery whose no current voltage measures 6.5 volts, the voltage in the battery if new falls below 5 volts, and if it is old it falls to below 3 volts. The new battery then is not able to produce a hot spark, and the old battery is not able to produce a spark at all. It is an object to illustrate how a voltage from the secondary of a conventional ignition coil may be amplified up to produce any desired dissipation of energy at the spark gaps.

These and other objects of the invention will be obvious from the following description, claims, and figures, wherein:

Fig. 1 shows an ignition system incorporating my invention, and

Fig. 2 shows how my invention may be readily adapted to a conventional ignition system with the use of less apparatus than in Fig. 1.

Referring to Fig. 1, a conventional rectifier system 32, drawing power from A. C. lines 10, furnishes power for the ignition system. This rectifier system consists of a rectifier tube 7, having a plate connected to each terminal of the secondary of a stepup transformer 8. The cathode of tube 7 is connected to ground 1, and the center tap of the secondary of transformer 8 through condenser 2 in parallel with resistance 3. Rectifier tube 6 has a plate connected to each terminal of secondary of transformer 9. The cathode of rectifier 6 is connected through condenser 4 in parallel with resistance 5 to the center tap of transformer 9 and to the cathode of tube 7.

The cathode of tube 6 is connected through inductance coils 11, and 13 to the plate of vacuum tube 17. The grid of tube 17 is connected through resistance 20 to the cathode of rectifier tube 7. The cathode of tube 17 is connected to the plate of vacuum tube 18. The screen grid of tube 18 is connected through resistance 21 to cathode of rectifier tube 7. The control grid of tube 18 is connected to a mid-point of voltage divider resistances 37, 38, which resistances are connected across the secondary of conventional ignition coil 34, the primary of which is supplied with current from battery 35 in series with interrupter 19, in parallel with condenser 36 in the conventional manner.

The plate of vacuum tube 17 is connected to distributor brush 31 through the anode and cathode of rectifier tube 15. The distributor brush 31, as it rotates makes contact with a plurality of contacts 29, 30 to ground 1 through one of

spark gaps 22, 23, 24, 25, 26, 27. Distributor brush 31 also is connected to the positive terminal of power supply 32 through a unidirectionally conductive gas discharge device 14 and current limiting resistance 33. The inductance 11 may be short circuited by key 12 for purposes herein-after described.

In operation when interrupter 19 is opened, a current passes from the grounded terminal of secondary of coil 34, through resistances 37, and 38 placing a negative potential on the control grid of tube 18. A high voltage surge is produced between the anode of vacuum tube 17 and ground as described in my U. S. Patent No. 2,328,444. This surge is passed from the anode to the cathode of rectifier 15, through distributor brush 31, to one of the contacts 29, 30 and then through one of the spark gaps 22—27 to ground 1. One of the spark gaps being broken down, condenser 4 in series with condenser 2 discharges through current limiting resistor 33, gas discharge device 14, distributor brush 31, and said broken down spark gap to ground 1. This shunt discharge current passing through device 14 is many times as large as the break down surge passing through rectifier 15 and is of sufficient value to melt the congealed oil on the terminals of the spark gap, so that the succeeding sparks pass across the gap more readily. This shunt discharge current also builds up the required ignition vapor pressure of gasoline by evaporizing the liquid gasoline spray suspended in the air in the vicinity of the spark gap and ignition takes place in the coldest temperatures.

After starting, key 12 is closed, shorting inductance 11, in order to permit production of ignition sparks to take place at a higher rate of speed than would be possible if both inductances 11 and 13 remained in the circuit.

To further illustrate the functioning of my device the constants of a circuit used in experimental work are given. It will be understood that my invention is not limited to the circuit values given or even to values of the same order, the invention being described in the claims.

In this experimental circuit rectifier tubes 6, 7 were type 80. Condensers 2 and 4 were 24 microfarads each. Resistances 3, 5 were 200,000 ohms each. Lines 10 were the 110 volt, 60 cycle power lines. Inductances 11 and 13 were each secondaries of conventional Ford ignition coils (30 henrys). Vacuum tube 17 was a type 809. Tube 18 was a type 2A5. Resistance 21 was 3000 ohms. Resistance 20 was 2000 ohms. Current limiting resistance 33 was 50 ohms. Gas discharge device 14 was a type 366 mercury rectifier. Rectifier 15 was a type 27 (grid and plate connected together). Resistance 37 was 2500 ohms. Resistance 38 was 10,000 ohms. Ignition coil 34, battery 35, interrupter 19, distributor arm 31, condenser 36, were those of a conventional six cylinder automobile. When the engine of the automobile was turned over, sparks about 1000 times as large as ordinary sparks could be drawn from the positive terminal of the spark plugs.

Fig. 2 shows how my invention may readily be adapted to the conventional ignition system in common use. Circuit elements performing the same function as those in Fig. 1, have been assigned the same reference numerals.

Referring to Fig. 2, the high tension line 52 was a conventional automobile distributor line, which connected the distributor to spark gap 27, and through said gap to ground 1, which was the frame of the automobile. In series with line 52

was inserted resistance 16, in parallel with condenser 28. The anode of gas discharge device 14 was connected to the high tension terminal of spark gap 27. The cathode of device 14 was connected to the negative terminal of power supply 32. The positive terminal of power supply 32 was connected through current limiting resistance 33 to ground 1.

When the engine of the automobile was turned over by the starter a high voltage pulse passed from the grounded terminal of the secondary of conventional ignition coil 53, through spark gap 27, condenser 28, high tension line 52, distributor arm 31, to the other terminal of the secondary of said ignition coil.

Spark gap 27 being broken down condensers 2 and 4 discharged through current limiting resistance 33, to ground, through spark gap 27, and gas discharge device 14. Sparks about a thousand times as large as the conventional sparks could be drawn from the high tension side of spark gap 27. Gas discharge device 14 (an 866) lighted up each time gap 27 broke down, and the discharge current was sufficiently large to light up current limiting resistance 33 each time a spark occurred, which resistance in that instance was a 40 watt, 110 volt tungsten filament light.

The energy content of the spark discharge through the circuit including condensers 2, 4, spark gap 27, gas discharge device 14 was substantially $\frac{1}{2}CE^2$. Since condensers 2 and 4 were each 24 microfarads and were connected in series the total capacity was 12 microfarads. The charge on these condensers totalled 700 volts. $\frac{1}{2}CE^2 = \frac{1}{2} \times 12 \times 10^{-6} \times 49 \times 10^4 = 3$ joules.

It is to be further noted that this energy was not dissipated by a high resistance path such as the secondary of an ignition coil but was dissipated to a large extent at the spark gap. From a consideration of the above energy formula it becomes obvious that the energy dissipated at the spark gap for a single discharge can be varied either by varying the capacity of the condenser, or the voltage impressed on said condenser.

In extremely cold weather it was found desirable to heat tube 14 indoors keeping it covered with a woolen covering, as it is well known that an 866 does not function properly when any part of the bulb is below 15 degrees centigrade. Heating this tube by means of an electrical pad also proved satisfactory.

One feature of my invention consists in means for rendering conductive a spark gap by a high voltage pulse, and a low impedance path for passing currents of large amperage through said broken down gap. While I have shown herein, what I believe to be the best form of my invention, various means for producing high voltage pulses are known, and various means for producing a low impedance path for passing currents of large amperage are also known. It is therefore

not desired to limit my invention to the apparatus which I have illustrated in detail. My invention is to be limited in scope only as defined in the following claims.

What I claim is:

1. In an ignition system, a first circuit comprising the series connection of a generator of a high voltage positive pulse, the anode and cathode of a spark gap, a second circuit comprising the series connection of an electrical energy storing source of current, the anode and cathode of a gas discharge device, and said anode and cathode of said spark gap, and means for applying said positive pulse to said anode of said spark gap to render said gap conductive and cause current to flow in said second circuit.

2. In an ignition system, a first circuit comprising a generator of a high voltage positive pulse, a resistance shunted by a condenser, the anode and cathode of a spark gap, a second circuit, comprising the anode and cathode of a gas discharge device, an electrical energy storing source of current, and said anode and said cathode of said spark gap, and means for applying said positive pulse to said anode of said spark gap to render said gap conductive and cause current to flow in said second circuit.

3. In an ignition system, a first circuit comprising the series connection of a generator of a high voltage pulse, the anode and cathode of a rectifier tube, and the anode and cathode terminal of a spark gap, a second circuit comprising the series connection of an electrical energy storing source of current, the anode and cathode of a second rectifier tube, the anode and cathode of said spark gap, and means for applying said pulse to said gap to render it conductive and cause current to flow in said second circuit.

4. In an ignition system, a first circuit comprising the series connection of a high voltage pulse generator, a resistance shunted by a condenser, a distributor, one of a plurality of spark gaps, a second circuit comprising the series connection of an electrical energy storing source of current, the anode and cathode of a rectifier, said distributor and said spark gap, and means for applying said high voltage pulse to said spark gap to render said first circuit conductive and cause current to flow in said second circuit.

5. In an ignition system, a first circuit comprising the series connection of a generator of a high voltage pulse, the anode and cathode of a spark gap, a second circuit comprising the series connection of an electrical energy storing source of current, the anode and cathode of a rectifier, and said anode and cathode of said spark gap, and means for applying said pulse to said anode of said spark gap to render said gap conductive and cause current to flow in said second circuit.

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