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3,332,409

PIEZOELECTRIC IGNITER AND DISTRIBUTOR

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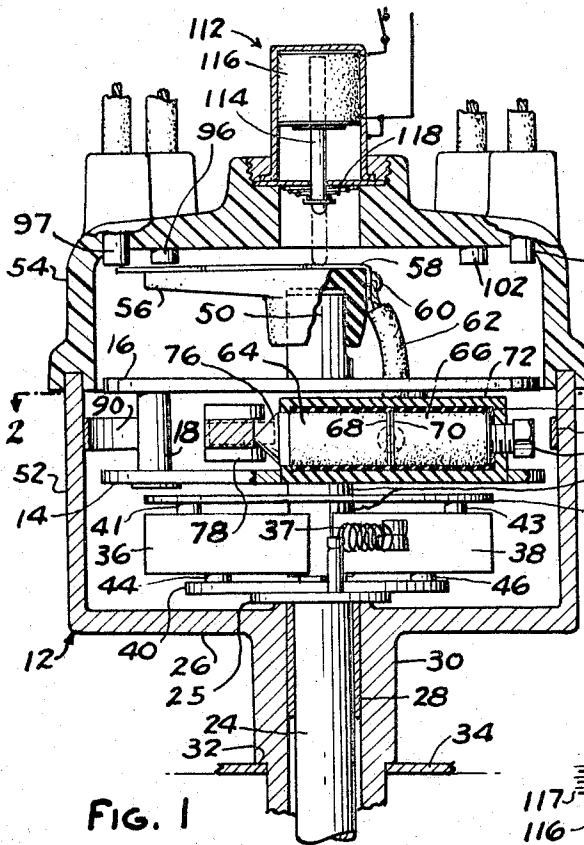


FIG. 1

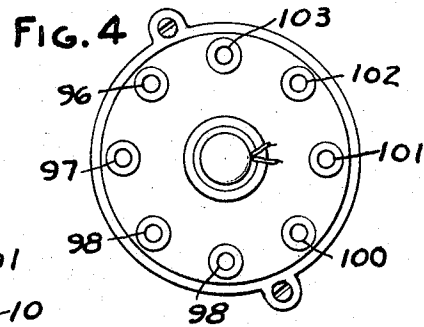


FIG. 4

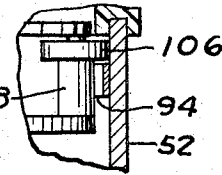


FIG. 3

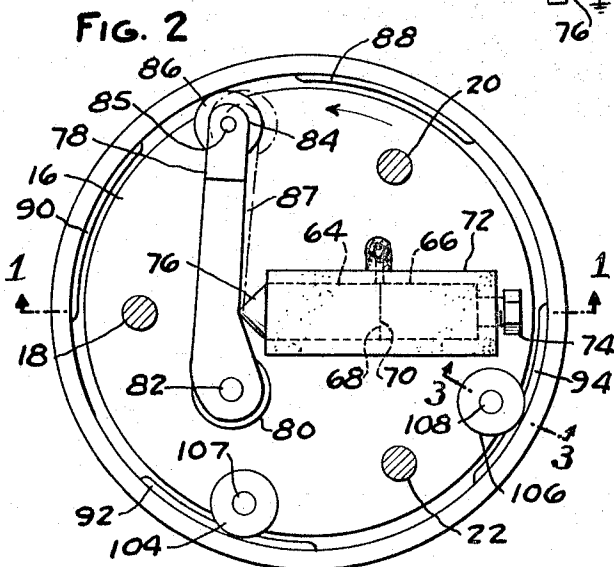


FIG. 2

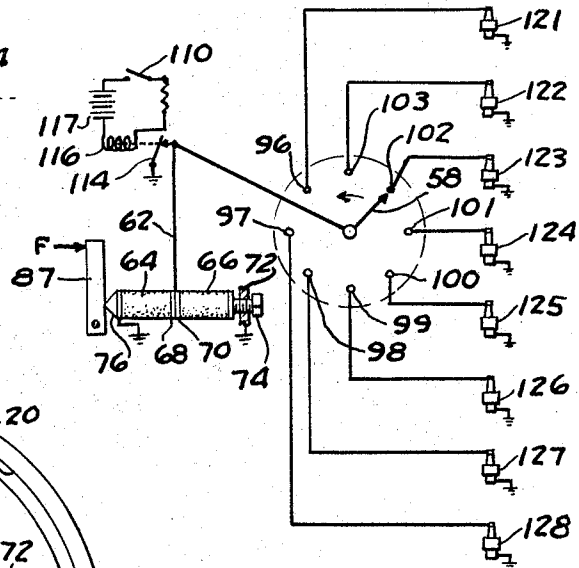


FIG. 5

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PIEZOELECTRIC IGNITER AND DISTRIBUTOR

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5 Claims. (Cl. 123-148)

ABSTRACT OF THE DISCLOSURE

A lever actuated piezoelectric spark pump is mounted on the rotary shaft of an ignition distributor of a multi-cylinder internal combustion engine for rotation with the shaft and associated distributor wiper arm. The lever has a follower portion which runs on a sinuous circular cam track stationarily supported by the distributor housing and oriented to stress the piezoelectric element of the spark pump via the lever so that firing voltage is generated by the pump in synchronism with the wiper arm passing by each of the distributor terminals in the distributor cap for sequential firing of the spark plugs of the engine.

This invention relates generally to ignition systems, and more particularly to a piezoelectric ignition and distributor unit.

In a piezoelectric ignition system, the high voltage required for firing the spark plugs of an internal combustion engine is derived from a piezoelectric element which is stressed in timed relation with the rotation of the engine shaft. Such piezoelectric systems are advantageous over the conventional breaker-condenser-coil ignition systems in that the piezoelectric systems do not draw ignition current from a battery, thereby eliminating some of the load on the usual automotive battery. The voltage supplied by the piezoelectric element is more constant than that supplied by magnetos. Ceramic polycrystalline piezoelectric elements are available commercially at the present time that are capable of withstanding the relatively great stress required to produce the high voltage needed for firing spark plugs.

An object of this invention is to facilitate conversion of the usual distributor of a conventional battery ignition system into a piezoelectric ignition and distributor unit.

Another object of the invention is to provide a piezoelectric igniter and distributor unit which can be driven by the distributor shaft of a conventional automotive distributor.

A further object of the invention is to reduce transverse loading of the driving shaft for a piezoelectric igniter and distributor so as to reduce wear of the shaft.

Another object of the invention is to provide a mechanism for automatically discharging the piezoelectric element of the unit when the ignition is turned off.

Other objects of the invention are to reduce noise, power consumption and time delays in a piezoelectric igniter and distributor unit.

Other objects, features and advantages of the present invention will be apparent in the following detailed description taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a vertical sectional view of a piezoelectric igniter and distributor unit in accordance with the invention taken on the line 1-1 of FIG. 2.

FIG. 2 is a sectional view of the unit of FIG. 1 taken on the line 2-2 of FIG. 1.

FIG. 3 is a fragmentary sectional view taken along line 3-3 of FIG. 2 and showing a reaction roller and a cam lobe of the unit.

FIG. 4 is a top plan view of the unit of FIG. 1 to a reduced scale.

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FIG. 5 is a diagram of the ignition circuit embodied in the unit.

Referring to FIGS. 1 and 2, the piezoelectric ignition distributor unit 10 of the present invention includes an annular housing 12 which serves as a stationary support structure and as an enclosure for two vertically spaced discs 14 and 16 which are interconnected by three posts 18, 20 and 22 and form a rotary support structure. The discs 14, 16 are rotated counterclockwise as viewed in FIG. 2 by a driving shaft 24 journaled in the bottom wall 26 of housing 12 by a suitable bushing 28. A sleeve 30 which projects downwardly from wall 26 is stepped down to provide a shoulder 32 to facilitate mounting unit 10 on a fixed support 34.

A conventional centrifugal spark advance mechanism including two weights 36 and 38 is mounted between two vertically spaced support discs 40 and 42. The weights 36, 38 are piloted on posts 44 and 46 affixed to disc 40. Posts 41 and 43 are affixed to weights 36 and 38 respectively, and disc 42 is piloted on posts 41, 43. Shaft 24 has a flange 25 connected to disc 40 and a stub shaft 48 is connected to disc 42 and is piloted on a stub end of shaft 24. At constant engine speed all of the discs rotate as a unit. As engine speed varies, disc 42 and the structure including the spark pumps affixed to it are rotated relative to disc 40 and shaft 24 by the action of the spark advance mechanism.

Another stub shaft or post 50 is fixed to the center of disc 16. A rotor 56 made of insulating material is rigidly secured to shaft 50 and has a conductor 58 affixed to its top side. A terminal screw 60 is provided for connecting an insulated lead 62 to conductor 58. The discs 14, 16, 40, 42 and shafts 24, 48, 50 are all made of metal. The cup-like base 52 of housing 12 is metallic, but the cap 54 is made of insulating material, preferably plastic.

Firing voltage is generated by the two piezoelectric ceramic slugs 64 and 66 each silvered at one end and mounted end-to-end with their respective silvered ends 68 and 70 abutting. Slugs 64 and 66 are maintained in this relationship by a metal holder 72 which is fixed to disc 14. Insulating material 73 extending around slugs 64, 66 isolates silvered ends 68, 70 from the metal holder 72. An adjusting screw 74 threads into one end of the holder for positioning slugs 64 and 66 axially within the holder. A pointed metal conductor 76 abuts the left-hand end of slug 64 as viewed in FIGS. 1 and 2.

Slugs 64 and 66 function in known manner as capacitors, conductor 76 and screw 74 serving as grounded capacitor electrodes and the silvered slug ends 68 and 70 serving as high potential capacitor electrodes. The metal holder 72 electrically and mechanically interconnects conductor 76 and screw 74 and is connected to ground potential via disc 14, shaft 48, disc 40 and shaft 24. The abutting silvered ends 68 and 70 of the slugs are connected by the high voltage lead 62 to the rotor terminal screw 60. Slugs 64 and 66 are thus electrically connected in parallel with each other and mechanically connected in series. More than two slugs may be used if desired, and a single slug can be made to work.

Axial compression forces are applied to the ceramic slugs by a lever 78 acting as a force-multiplying second class lever. The inner end 80 of lever 78 is pivotally supported on a fulcrum post 82 extending between and supported by discs 14 and 16. The outer end 84 of the lever is bifurcated and carries a journal pin 85 which in turn rotatably supports a cam follower roller 86. The pointed conductor 76 bears against and rides in the vertex of the V-shaped side 87 of lever 78. Lever 78 functions as an actuating means for mechanically stressing the slugs, and the slugs and lever together serve as a spark pump. The

entire spark pump and rotor assembly rotates with the spark advance mechanism 36, 38.

As the spark pump rotates counterclockwise as viewed in FIG. 2, roller 86 tracks in alternating sequence on the inner circular periphery of distributor housing 11 and on one of a series of four or more cam lobes 88, 90, 92 and 94 mounted on the inner wall of the housing. When roller 86 strikes the leading edge or entrance ramp of each cam lobe, lever 78 is forcibly pivoted clockwise as viewed in FIG. 2 so that it exerts axial compression force on ceramic slugs 64 and 66. The squeezing of the slugs causes them to acquire a charge. The voltage developed is proportional to the pressure and for most practical purposes may be regarded as appearing instantaneously. As will be explained further, the slugs also acquire a charge when they are released, and the voltage developed upon releasing a pressure is opposite in polarity to the voltage produced by squeezing.

The material of the slugs may be a polycrystalline ceramic, preferably composed of metallic titanates. The ceramic is a good insulator with a relatively high dielectric constant. Thus, the slugs have rather high capacitance for their size. For a specific available ceramic slug, if a force of 7,000 p.s.i. is exerted on the slugs, a potential of 21,000 volts will be developed between the high voltage lead connected to their silvered ends and the grounded outer ends of the slugs. The charge and voltage developed by compression of the slugs will be maintained by the pressure, but some leakage will occur. Therefore, it is desirable to discharge the slugs through a spark plug immediately after they are compressed in order to utilize the maximum voltage available from the slugs.

Except for the short entrance and exit ramps, cam lobes 88, 90, 92 and 94 are of constant radius and thus, so long as cam follower roller 86 is riding on a cam lobe, such as cam lobe 90, the high voltage potential is maintained. Shortly after cam follower roller 86 rides up the entrance ramp of cam lobe 90, the rotor 56 wipes under a terminal 96. There are eight high tension terminals 96-103 (FIG. 5) which lead through the cap 54 and rotor conductor 58 and the high tension terminals constitute a rotary switching device. The terminals are connected by insulated cables to spark plugs 121-128 (FIG. 5). As rotor 56 passes under terminal 96, rotor conductor 58 connects the charged slugs 64 and 66 to spark plug 121 which then fires, thereby discharging the slugs.

Cam follower roller 86 continues riding along the constant radius portion of cam lobe 90 and then rides down the exit ramp of the cam lobe. This releases slugs 64 and 66 and causes them to acquire a charge again, but this time the voltage developed across the slugs is of the opposite polarity. The particular slugs described above become charged positively when they are compressed, and after discharging, they become negatively charged when they are released. The negative voltage may be used to fire another spark plug or it may be simply discharged to ground. In either case, rotor conductor 58 wipes under high tension terminal 97 just after cam follower roller 86 rides down the exit ramp of cam lobe 90. At this time, slugs 64 and 66 are in circuit with spark plug 128 and cause it to fire, thereby discharging the slugs. The charging and discharging sequence which has been described in connection with cam lobe 90 is repeated as the cam follower roller 86 engages successive cam lobes.

In FIG. 5, each of the terminals 96-103 is connected to a spark plug since the connections for an eight cylinder engine are illustrated. In this case, four spark plugs are fired by negative voltage. It is to be understood, however, that for a four cylinder engine, terminals 97, 99, 101 and 103 may be connected to ground potential.

Shaft 24 may be the usual distributor shaft which is driven by the engine crankshaft. The spark pump assembly is oriented relative to shaft 24 and cam lobes 88, 90, 92 and 94 to cause each spark plug to fire as the associated piston is approaching the top of its compression

stroke. This orientation is varied in order to retard or advance the spark in response to engine speed by the centrifugally actuated weights 36, 38 of the spark advance mechanism. The centrifugal force acting on weights 36, 38 as they revolve with shaft 24 tends to throw them outward against the tension of spring 37 to thereby rotate disc 42 and the structure affixed thereto relative to disc 40 and shaft 24, thereby changing the orientation of the spark pump relative to the distributor shaft.

A pair of reaction rollers 104 and 106 (FIG. 2) are rotatably supported on posts 107 and 108 extending between and secured to discs 14 and 16 in opposed balanced relation to roller 86 to take the radial loading imposed by roller 86, thereby relieving the center shaft 24 of this load. Reaction rollers 104 and 106 track on the constant radius inner wall of the housing, one above and one below the cam lobes. The position of roller 106 above cam lobe 94 is evident in FIG. 3.

The invention also provides a device for discharging slugs 64 and 66 when the ignition switch 110 (FIG. 5) is turned off. This device 112 (FIGS. 1 and 5) consists of a shorting contactor or rod 114 which is raised upwardly by energizing a solenoid 116 which is connected to battery 117. Solenoid 116 is energized by turning on (closing) the ignition switch 110. The energized solenoid holds the lower end of the shorting rod spaced from the rotor (FIG. 1). Turning off the ignition (opening switch 110) de-energizes the solenoid, whereupon a spring 118 urges the shorting rod downwardly until its lower end contacts the rotor. This connects the high voltage electrode of the spark pump to ground, thereby shorting out the spark plugs so that ignition cannot occur and allowing the slugs to discharge.

The piezoelectric igniter and distributor unit which has been described can be assembled with and operated from the distributor shaft ordinarily provided in automotive vehicles. Thus, no special auxiliary apparatus is required to accommodate the unit. The unit itself utilizes some of the usual structure of conventional distributors to good advantage. The spark pump assembly is integrated with the conventional structure just referred to. The usual breaker points, ignition coil, capacitor and battery connections (and the attendant drain on the battery) are eliminated. Side loading of the distributor shaft has been minimized to reduce wear. Residual charge on the piezoelectric element or elements could result in firing of one or more plugs after turning off the ignition. This possibility is obviated by providing an alternate discharge path for the piezoelectric elements which is rendered effective when the ignition is turned off.

I claim:

1. A piezoelectric igniter and distributor unit comprising a housing having a cup-like base having an end wall and an annular side wall and a removable cap closing the mouth of said base, a distributor shaft extending through said end wall of said base, a rotary support structure in said housing connected to said distributor shaft to be rotated thereby, a spark advance mechanism carried by said rotary support structure and located adjacent said end wall, a distributor rotor affixed to said rotary support structure and located adjacent to said cap and a plurality of terminals leading through said cap and having contact portions in said housing arranged sequentially in the path of said rotor, wherein the improvement comprises a spark pump assembly carried by said rotary support structure and located between said spark advance mechanism and said rotor, cam means carried stationarily on said cup-like base and having cam lobes spaced along a circular path about the rotation axis of said rotary support structure, said spark pump assembly including a piezoelectric element having electrodes therefor, lever actuating means for stressing said piezoelectric element and having a follower portion at said circular path for engaging said cam lobes, said cam lobes, said lever means and said rotor being oriented relative to one another

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er whereby said piezoelectric element is stressed by the sequential interengagement of said cam lobes and said follower portion in response to rotation of said rotary support structure relative to said housing to produce a pulsating voltage on said element electrodes which peaks in synchronism with said rotor passing said contact portions of each of said terminals, means electrically connecting one electrode of said piezoelectric element to said rotor and electrically connecting another electrode of said piezoelectric element to a point of reference potential, and circuit means electrically connected to said one electrode of said piezoelectric element and to a point of electric potential providing a discharge path in shunting circuit relation with said terminals, said circuit means including a switching device mounted on said cap operable to close and open said shunting discharge path.

2. Ignition apparatus for a multiple cylinder spark plug ignition internal combustion engine comprising a closed distributor housing having end walls at opposite ends thereof, a distributor shaft adapted to be rotatably driven by said engine and having one end extending through one of said end walls into said housing, a plurality of terminals adapted to be electrically connected one to each of the spark plugs of the engine and being supported in the other one of said end walls and having exposed portions arranged in a circular row within said housing, rotary support means mounted on said one end of said shaft for rotation therewith in said housing and a distributor rotor carried on said rotary support means and having a conductive portion disposed for travel along said circular row, wherein the improvement comprises cam means stationarily mounted on said housing in the interior thereof having a plurality of cam lobes circumferentially spaced along a circular path adjacent said rotary support means, a piezoelectric element mounted on said rotary support means for rotation therewith and having electrodes therefor, lever means pivotally mounted on said rotary support means for rotation therewith and being operably connected to said piezoelectric element to apply stressing force thereto, said lever means having follower means disposed to successively engage said cam lobes and thereby sequentially apply and remove stressing force to said piezoelectric element via said lever means in response to rotation of said rotary support means relative to said cam means, means electrically connecting one electrode of said piezoelectric element to said rotor and connecting another electrode of said element to a

point of reference potential, said lobes, said follower means and said rotor being oriented relative to one another whereby said sequential stressing of said element produces a pulsating voltage on said rotor which peaks in synchronism with said conductive portion of said rotor passing each of said exposed terminal portions.

3. The apparatus as set forth in claim 2 wherein said lever means is fulcrumed on said rotary support means and is operably connected to said piezoelectric element at a point along said lever means between said follower means and the fulcrum point of said lever means whereby said lever means operates as a second class lever.

4. The apparatus as set forth in claim 2 wherein the improvement further comprises reaction means carried on said rotary support means for rotation therewith and track means stationarily supported by said housing along the path of travel of said reaction means for engagement by said reaction means to thereby balance forces applied to said rotary support means by the engagement of said follower means with said cam lobes during rotation of said rotary support means relative to said housing.

5. The apparatus set forth in claim 4 wherein said housing has an annular side wall between said end walls and said cam lobes are mounted on the interior surface of said side wall in a path encircling said rotary means, wherein said follower means comprises first roller means rotatably mounted on said lever means for rolling engagement with said cam means, wherein said reaction means comprises second roller means rotatably mounted on said rotary support means in spaced relation from said first roller means, and wherein said track means comprises a cylindrical portion of said side wall disposed concentric with said rotary support means and adjacent said cam means, said second roller means having rolling engagement with said cylindrical portion.

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**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

Patent No. 3,332,409

July 25, 1967

Lawrence E. Hoover

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 10, for "pump" read -- generating ignition device --; same column 1, line 18, column 3, lines 1, 3 and 72, and column 4, lines 9, 31 and 40, for "pump, each occurrence, read -- generator --; column 1, line 19, for "pump" read -- spark generator --; column 2, line 71, for "spark pump." read -- piezoelectric ignition device such as that sold under the trademark "Spark Pump" by Clevite Corporation of Cleveland, Ohio, and referred to hereinafter as a "spark generator". --.

Signed and sealed this 5th day of November 1968.

(SEAL)

Attest:

Edward M. Fletcher, Jr.

Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents