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Hoover

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[45] **June 5, 1973**

[54] PIEZOELECTRIC DISTRIBUTOR

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[73] Assignees: **Anthony Tramastozzi,** Detriot; **Constantine Papas,** Southfield, Mich. ; part interest to each

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[21] Appl. No.: **194,590**

Related U.S. Application Data

[62] Division of Ser. No. 839,445, July 7, 1969, Pat. No. 3,622,717.

[52] **U.S. Cl.** .....**310/8.7,** 317/DIG. 11, 123/148 BA

[51] **Int. Cl.** **H04r 17/00**

[58] **Field of Search**.....310/8.3, 8.7, 9.1, 310/8.1; 317/DIG. 11, 79, 81; 123/148 BA

[56] **References Cited**

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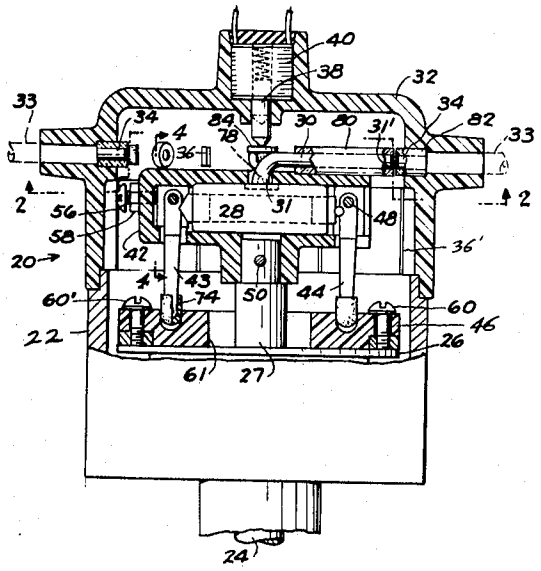
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Assistant Examiner—Mark O. Budd
Attorney—Barnes, Kisselle, Raisch & Choate

[57] **ABSTRACT**

A piezoelectric generator and distributor unit for a spark ignition internal combustion engine in which a piezoelectric element is mounted in a body carried by a rotor shaft for rotation therewith. Two lever arms are pivoted on the body and engage opposed ends of the element. A plate with a cam track is fixed with respect to the rotor and engages the lower ends of the levers so that rotation of the rotor and body causes the levers alternately to compress and release the element which develops a charge at a high potential in response to being stressed by the levers. A central rotor terminal and terminals in a distributor cap provide a conductive path for transmitting charges from the unit. These terminals are surrounded by heat and electrically insulating tubes which extend beyond the ends of the terminals to provide a shield which eliminates the corona and premature arcing problems of high voltage switching in this type of distributor.

10 Claims, 8 Drawing Figures



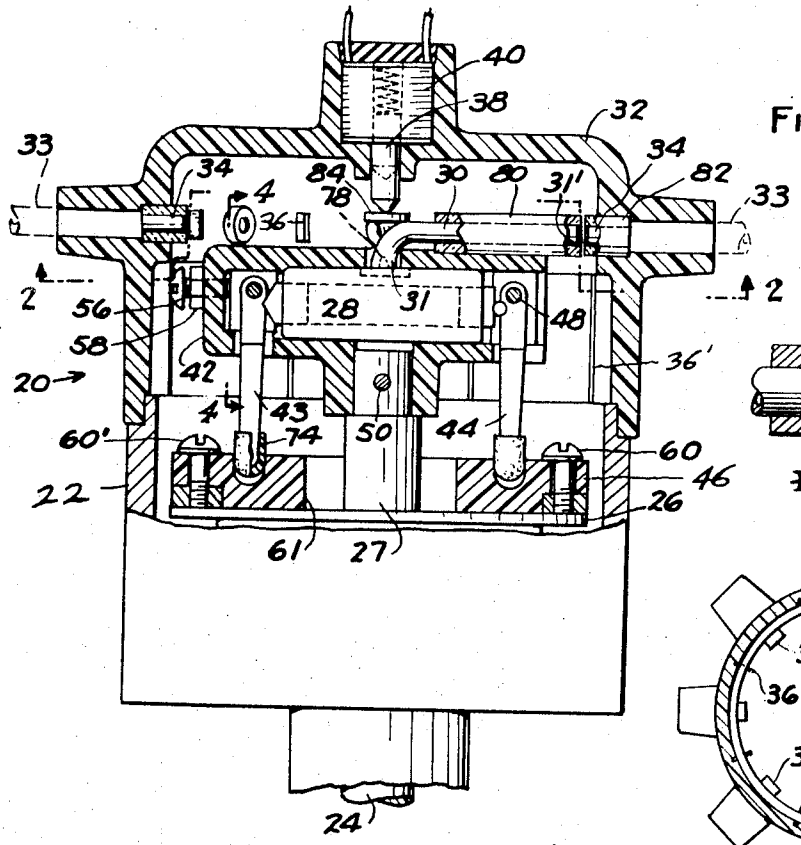


FIG. 1

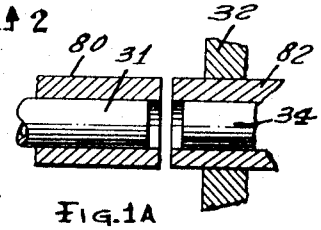


FIG. 1A

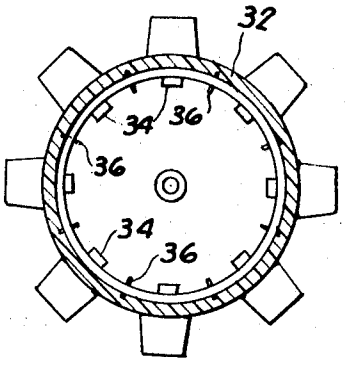


FIG. 2

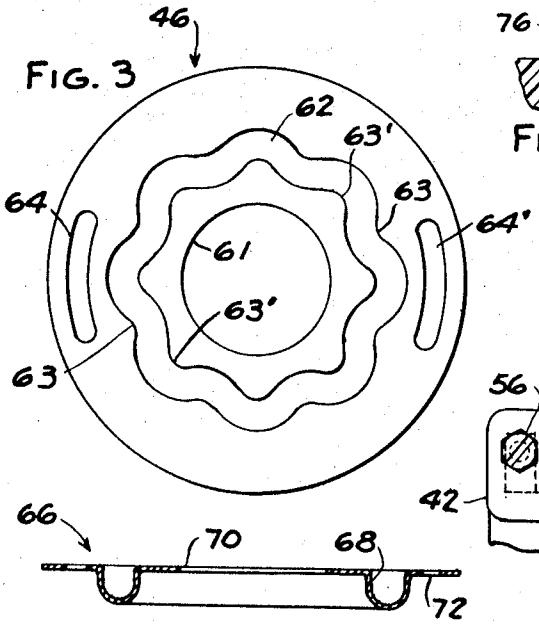


FIG. 3

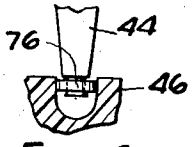


FIG. 6

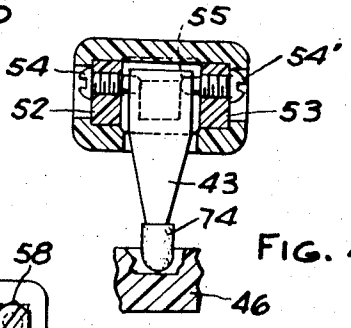


FIG. 4

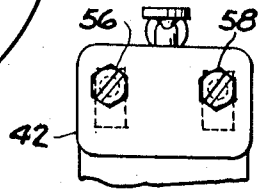


FIG. 5

FIG. 7

PIEZOELECTRIC DISTRIBUTOR

This is a division of application Ser. No. 839,445, filed July 7, 1969, now U.S. Pat. No. 3,622,717.

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

In a piezoelectric ignition system the high potential required for firing the spark plugs of an internal combustion engine is derived from a piezoelectric crystal or element which is stressed in timed relation with the rotation of the engine crankshaft to provide a pulsed electrical output with sufficient electromotive force to fire the spark plugs.

An object of this invention is to provide a means of readily converting a conventional automotive ignition distributor into a piezoelectric generator and distributor unit.

Another object of this invention is to reduce the transverse loading of the driving shaft of a piezoelectric generator and distributor unit, thereby reducing the wear on the driving shaft and its journal.

Another object of this invention is to provide a means of preventing corona discharge and premature arcing between the rotor and terminal electrodes of the piezoelectric ignition distributor unit.

These and other objects, features and advantages of the invention are described in this specification and illustrated in the drawings in which the manner and process of making the invention in the best mode contemplated by the inventor is disclosed by way of example only, for, since the underlying principles may be incorporated in other constructions, it is not intended to be limited to those shown, except as such limitations are clearly imposed by the appended claims.

In the drawings:

FIG. 1 is a vertical sectional view of a piezoelectric generator and distributor unit of this invention.

FIG. 2 is a sectional view on line 2—2 of FIG. 1 illustrating the high tension spark plug and ground terminals.

FIG. 3 is a plan view of the cam plate only of FIG. 1.

FIG. 4 is a sectional view on line 4—4 of FIG. 1 illustrating a pivot screw mounting of one of the lever arms.

FIG. 5 is an end view of the left hand end (as viewed in FIG. 1) of the carrier body for the piezoelectric elements illustrating the adjustment screws for varying the pressure applied to the piezoelectric element.

FIG. 6 is a view of an alternate construction of a lever arm cam track follower.

FIG. 7 is an elevational view in section of a second embodiment of the cam plate of FIG. 1.

Referring to the drawings:

The present invention is an improvement upon the piezoelectric generator and distributor unit disclosed and claimed in my U. S. Pat. No. 3,332,409 issued on July 25, 1967, to which reference may be had for a detailed description of some of the structure and general mode of operation of my improved unit disclosed herein.

FIG. 1 illustrates a piezoelectric ignition distributor unit **20** constructed in accordance with the improved features of my present invention. Unit **20** comprises an annular housing **22**, driving shaft **24**, a support plate **26** connected to housing **22**, a rotor shaft **27**, a piezoelectric element **28**, a center electrode **30**, and a distributor cap **32** removably mounted on housing **22**. Cap **32** has a plurality of high tension leads **33** each terminating at

an electrode **34**, grounding electrodes **36** (FIG. 2) and a center grounding electrode **38** actuated by a solenoid **40**. Housing **22**, drive shaft **24**, support plate **26** (which normally carries breaker points and a condenser) and rotor shaft **27** may be and preferably are existing standard components already available as part of the usual distributor of an automobile engine normally adapted for use with a conventional ignition system with a battery, breaker, condenser, and coil. A suitable piezoelectric element **28** for this generator and distributor unit may be a piezoelectric ceramic tube or solid cylinder obtainable from the Clevite Electronic Components Division of Clevite Corporation of Cleveland, Ohio, as set forth in their Bulletin No. 9244–1 dated March, 1961 and other publications.

Generator-distributor unit **20** develops a current with a high electrical potential difference for firing a spark plug by applying a mechanical compressive force to piezoelectric element **28**. This compressive force is developed by mounting piezoelectric ceramic element **28** in a carrier body **42** between two second-class levers **43** and **44**. Levers **43** and **44** bear on piezoelectric element **28** and engage a die cast cam plate **46** so that rotary movement of carrier body **42** caused by rotation of shaft **27** with respect to cam plate **46** causes the levers to pivot in unison and apply a compressive force of varying magnitude along the longitudinal center line of piezoelectric element **28**. The magnitude of the compressive force is varied or adjusted by moving the pivot point of lever arm **43**. Lever arm **44** is pivotally mounted on a pin **48** extending through body **42**, and body **42** is connected to rotor shaft **27** for rotation therewith by a pin **50**. As shown in FIG. **4**, lever arm **43** is pivotally mounted between a pair of blocks **52** and **53** by pivot screws **54** and **54'** respectively mounted in blocks **52** and **53** and which engage in two opposed recesses **55** in lever arm **43**. As shown in FIG. **5**, a pair of screws **56** with locknuts **58** threadingly engage with and protrude through the end of body **42** to bear on blocks **52** and **53** respectively. Blocks **52** and **53** are slidably captured within body **42** so that they can be moved longitudinally to urge pivot arm **43** into engagement with piezoelectric element **28**. Since the pivot point of arm **44** is fixed in body **42**, adjustment of screws **56** varies the total force developed by lever arms **43** and **44** when they are urged toward each other by cam plate **46**.

Cam plate **46** which controls the movement of levers **43** and **44** is connected by screws **60** and **60'** (FIG. 1) to a conventional breaker and condenser mounting plate **26**. As shown in FIG. **3**, cam plate **46** is a flat annular plate with a central aperture **61**, an annular radially sinuous cam track **62** coaxial with aperture **60**, and two diametrically opposed arcuate slots **64** and **64'** extending through the plate coaxial with aperture **60**. Slots **64** and **64'** allow cam plate **46** to be rotated with respect to fixed support plate **26** and terminals **34** to adjust the point with respect to terminals **34** at which cam plate **46** causes lever arms **43** and **44** to exert the maximum compressive force on element **28**. Cam track **62** is formed with four pairs of diametrically opposed circularly spaced cam lobes **63** so that piezoelectric element **28** will be squeezed and released eight times in 360° of rotation of body **42** with respect to cam plate **46**. This provides the correct number of pulses or changes in the electrical potential or output of piezo-

electric element 28 for the firing of an eight-cylinder engine, as will be explained in detail hereafter.

A second embodiment of a cam plate similar to plate 46 is shown in FIG. 7 in which the modified cam plate 66 is a sheet metal stamping with a cam track 68 in the form of a generally U-shaped channel, a pierced central aperture 70 and circumferential slots 72.

As shown in FIGS. 1 and 4, a semi-spherical tip 74 of a wear resistant material with a low coefficient of friction, such as the fluorocarbon plastic material sold under the trademark Teflon, is mounted on the lower extremity of each lever arm 43 and 44 to provide a low friction cam follower for each lever arm. Alternatively, as shown in FIG. 6, a roller 76 can be journalled on a cylindrical end tip of each lever arm and secured by staking or peening the tip to provide a suitable cam follower.

The lever arms 43 and 44 and the cam plate 46 or 66 provide a structure for applying a compressive force to piezoelectric element 28 in which the reaction to the compressive force is balanced in the cam plate and carrier body 42 so that an unbalanced force or side thrust is not transmitted to rotor shaft 27 and its journal. Hence, this structure reduces the transverse loading and resultant wear on the rotor and drive shaft of the unit 20. The shape of the cam track is such that it captures or positively limits the travel in both directions of the lever arms so that they will not "bounce" or be subjected to extraneous movements due to their inertia when the generator and distributor unit is operating at relatively high speeds. By slidably mounting piezoelectric element 28 in body 42 so that it is restrained from shifting slightly longitudinally only by engagement with arms 43 and 44, it will compensate for manufacturing tolerances, wear and errors in producing and assembling the components of the unit so that the reaction forces due to the compression of piezoelectric element 28 will always have substantially the same magnitude on each side of shaft 27 and hence will be properly balanced.

When center electrode 30 is aligned with a terminal electrode 34, it provides a conductive path for the high potential developed by piezoelectric element 28 when it is compressed. Center electrode 30 is made of an electrically conductive metal, such as copper, formed in the shape of an L with its short leg 31 mounted centrally on element 28 and electrically connected to one of its output terminals at 78. The long leg 31' of electrode 30 extends radially above carrier 42 and is sheathed in a tube 80 of electrical and heat insulating material, such as the heat and electrically insulating glass sold under the trademark Pyrex. The radially outer end portion of tube 80 extends or projects axially of electrode 30 slightly beyond the free end thereof. Terminal electrodes 34 are each formed from an electrically conductive metal, such as copper, and are mounted in a circumferentially spaced radially extending array in the outer wall of cap 32. A glass insulating tube 82, made of the same material as tube 80, sheaths the radially inner end of each electrode 34 and projects inwardly slightly beyond the inner end of the electrode. Preferably, there is a space of approximately 0.015–0.020 inches between adjacent faces of central electrode 30 and a terminal electrode 34 when they are axially aligned with each other, and tubes 80 and 82 each preferably extend approximately 0.005 inches beyond the outer edge of their associated terminal. The recessing of the end faces of electrodes 30 and 34, provided by the extension of tubes 80 and 82 beyond their respective terminals provides a refractory quality heat and electrical insulating shield which reduces or eliminates corona discharge and premature arcing problems encountered with the use of this type of distributor when it is used in high r.p.m. applications and to supply ignition currents of high potential. An electrically conductive pad 84 of a metal such as copper is positioned coaxially of the rotational axis of carrier 42 so as to underlie grounding electrode 38 and is electrically and mechanically connected to electrode 30 so that it can be physically contacted by electrode 38 when solenoid 40 is de-energized.

In operation, when a set of diametrically opposed lobes 63 of cam plate 46 or 66 urge levers 43 and 44 toward each other due to the rotation of carrier 42 by shaft 27, an axial compressive force is applied to piezoelectric element 28 which causes it to develop a charge at a high potential which is then conducted through central electrode 30 to a terminal electrode 34 via the air gap therebetween when they become axially aligned. Preferably, lobes 63 are oriented relative to electrodes 30 and 34 so that peak voltage is developed when such alignment occurs. Thereafter as shaft 27 and carrier body 42 continue to rotate, lever arms 43 and 44 are urged away from each other by the diametrically opposed inner lobes 63' of track 62, which releases or decreases the compressive force acting on piezoelectric element 28. This decrease in the compressive force acting on element 28 after it has been discharged causes it to become charged again at a high potential with a polarity opposite to the polarity of the charge caused by compression of element 28. This charge of opposite polarity can be conducted through another terminal and either used to fire a spark plug or may be bled to a common ground, thereby again discharging element 28.

If it is desired to use only charges having the same polarity to fire the spark plugs, a plurality of ground electrodes 36, and associated ground connector strips 36' leading to housing 22, (as shown in FIG. 2) are provided one between each adjacent pair of electrodes 34 in circumferentially alternating relationship therewith so that all charges of one polarity are conducted from element 28 through terminal electrodes 34 and all charges of the opposite polarity are conducted from element 28 through electrodes 36 which are suitably connected to a common ground. By thus sequentially connecting each electrode 36 and one output terminal of element 28 to a common ground, the charges of one polarity developed by element 28 are dissipated through the ground circuit, and in alternating sequence therewith the charges of the opposite polarity are transmitted from the distributor through the ignition circuit distribution electrodes 34. This arrangement allows all of the spark plugs connected to terminals 34 to be fired by a sparking potential of like polarity, which may be that selected to best match the characteristics of the type of spark plugs being fired. However, it should be noted that use of a current having only one polarity merely represents an optimum condition for certain applications, and in other applications that highly satisfactory results can be obtained if both the positive and negative current pulses produced by element 28 are utilized. In the latter situation, it is only necessary to provide a cam plate with four squeezing lobes and four

release lobes, and grounding terminals **36** may be eliminated from cap **32** if it is desired to use both the positive and negative current pulses of element **28** for an eight pulse output.

As set forth in my aforementioned U.S. Pat. No. 3,332,409, to provide a convenient means of de-energizing a piezoelectric ignition system so that a spark ignition engine on which the system is used can be shut down, the yieldably biased shorting terminal **38** is connected to the ground side of element **28** so that when solenoid **40** is de-energized terminal **38** contacts disc **84** whereby the ignition leads **33** are shunted and both the positive and negative current pulses of element **28** are dissipated in the ground circuit. When solenoid **40** is energized, as by turning the ignition switch to "on" position, terminal **38** is disengaged from disc **84**; thereby removing the shunt path and causing current flow via central terminal **30** and ignition circuit terminals **34**.

From the foregoing description, it will now be apparent that piezoelectric generator and distributor unit **20** is adapted to utilize many of the components of ordinary distributors found on most automotive and commercial spark ignition engines. The dual lever arm and cam plate structure provides a means of equalizing or balancing the opposed reactionary forces created by compressing the piezoelectric element so that a transverse load is not transmitted to the rotor and driving shafts, thereby reducing the wear and stress on these shafts and their associated journals. The stamped sheet metal cam plate **66** provides a unit which can be economically manufactured. The channel-shaped track **68** of the cam plate entraps the lower end of each lever arm so that the inertia of their pivoting mass does not cause them to bounce and thereby impede the efficiency of the piezoelectric unit when it is operated at relatively high speeds. The glass shields extending beyond the ends of the rotating center and stationary exit terminals provide an inexpensive heat resistant electrical insulator which eliminates the corona discharge and premature arcing which otherwise would adversely effect performance and efficiency. This is particularly advantageous when this type of distributor unit is used on an internal combustion engine operated at relatively high speeds because even a slightly premature ignition of the fuel in an internal combustion engine can have a substantial adverse effect on its high speed performance.

I claim:

1. In a piezoelectric generator and distributor unit having a stationary housing including a cup-like base with an end wall, a removable cap closing the mouth of the base, a distributor shaft extending through said end wall of said base, a rotor support structure in said housing connected to said distributor shaft to be rotated thereby, a plurality of circumferentially spaced terminals leading through said cap and having an end portion therein, and a rotor terminal carried by the rotor support structure having a portion sequentially juxtaposed in arc gap relation with said cap terminals in response to rotation of said rotor support structure, the improvement which comprises:

a. a body connected to the rotor support structure for rotation therewith,

b. a piezoelectric element carried by said body and having two axially opposite ends disposed on opposite sides of said shaft,

c. two lever arms pivotally carried on said body, said arms being pivotally engageable one with each of the opposite ends of said element and extending generally axially of the rotor support structure,

d. cam means having at least two diametrically opposed cam lobes lying in a plane generally transverse to the axis of rotation of the rotor support structure, said cam means being carried in said base in fixed relationship thereto and being engageable with said levers to urge said levers into engagement with said ends of said element in response to rotary movement of the rotor support structure, and

e. means electrically connecting an output terminal of said element to said rotor terminal to thereby connect said element sequentially in circuit with said cap terminals.

2. The unit as defined in claim **1** in which said cam means is a plate having a cam track therein defining said two lobes with said levers each having a follower end engaging said track.

3. The unit as defined in claim **2** in which said track comprises a groove in said plate having opposite side walls engaging each of said follower ends of said levers.

4. The unit as defined in claim **2** in which said plate is a sheet metal stamping having a channel with a generally U-shaped cross section forming said cam track.

5. The unit as defined in claim **1** in which said body slidably carries a block on which one of said lever arms is pivoted, and adjustable means for moving said block and its associated lever arm toward the associated end of said element.

6. The unit as defined in claim **1** in which each of said levers has a follower at one end thereof engageable by said lobes, each said lever being pivotally carried by said body adjacent an end thereof opposite said one end thereof, each said lever engaging the associated end of said element between said ends of said lever whereby each of said levers operates as a second-class lever.

7. The unit as defined in claim **1** in which said element is movable along its longitudinal axis between said levers whereby said element is self-centering relative to said levers in response to said levers bearing on said element.

8. The unit as defined in claim **1** wherein said means of subparagraph (e) comprises:

a. a central terminal of an electrically conductive material electrically connected to an output terminal of said piezoelectric element and carried by said body for rotation therewith, an end of said central terminal being positioned to pass sequentially in proximity to said ends of said plurality of cap terminals when said body is rotated,

b. a shield of an electrically insulative material circumscribing at least a portion of said central terminal and extending beyond said end of said central terminal, and

c. shields of an electrically insulative material, one circumscribing at least a portion of each of said cap terminals and extending beyond the end portion thereof.

9. The unit as defined in claim **8** in which each of said shields projects at least about 0.005 inches beyond the end of its associated terminal.

10. The unit as defined in claim **8** in which said insulative material is made of heat resistant and electrically insulating glass.

* * * * *