United States Patent

[11] 3,622,717

[72] Inventor **Lawrence E. Hoover**
Detroit, Mich.

[21] Appl. No. **839,445**
[22] Filed **July 7, 1969**
[45] Patented **Nov. 23, 1971**

[73] Assignee **Anthony Tramontozzi**
Detroit, Mich.
a part interest

[54] **PIEZOELECTRIC DISTRIBUTOR WITH IMPROVED CONTACT INSULATIVE SHIELDING STRUCTURE**
4 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **200/23,** 200/26, 200/30
[51] **Int. Cl.** **H01h 19/00,** H01h 19/62
[50] **Field of Search** ..... 200/8, 19–32, 149.2, 153.14, 166 I, 168 GI

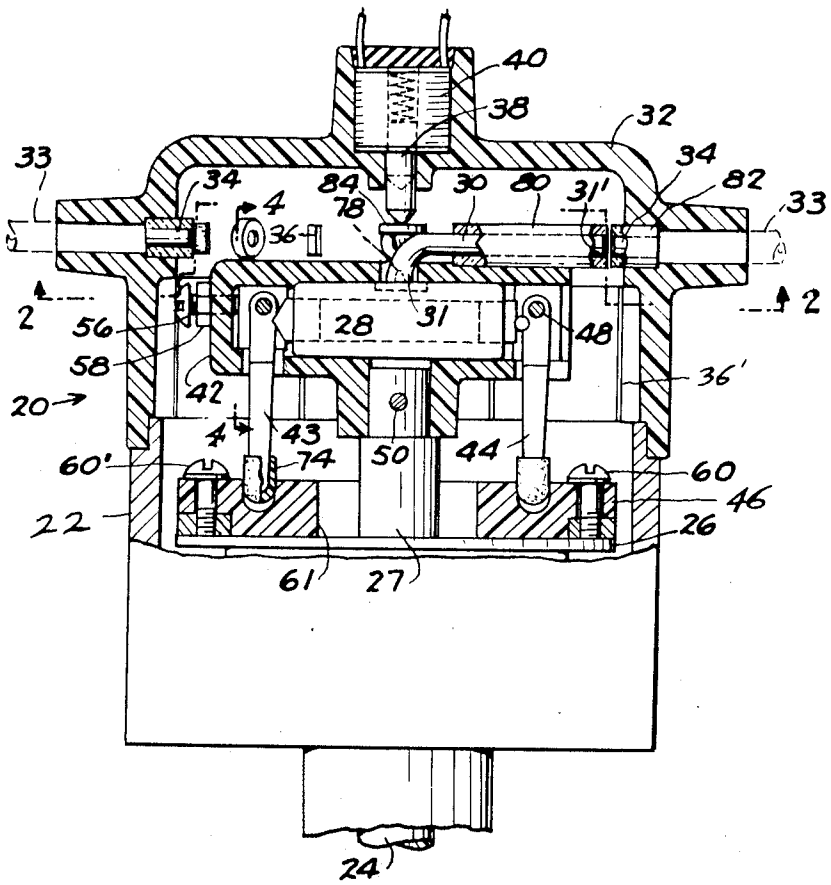
[56] **References Cited**

UNITED STATES PATENTS

2,034,683	3/1936	Olandt	200/19 X
2,574,616	11/1951	Brown	200/28
2,619,555	11/1952	Westfall	200/19
2,694,117	11/1954	Bakke	200/19
2,723,319	11/1955	Sebring et al.	200/8
2,734,969	2/1956	Mallory	200/30 X
2,756,293	7/1956	Bitler	200/8 UX
2,774,831	12/1956	Lafferty et al.	200/22 X
2,984,715	5/1961	Brinster et al.	200/24 X
3,005,078	10/1961	Motto et al.	200/26 X
3,217,216	11/1965	Dotto	200/24 X

Primary Examiner—J. R. Scott
Attorney—Hauke, Gifford & Patalides

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.



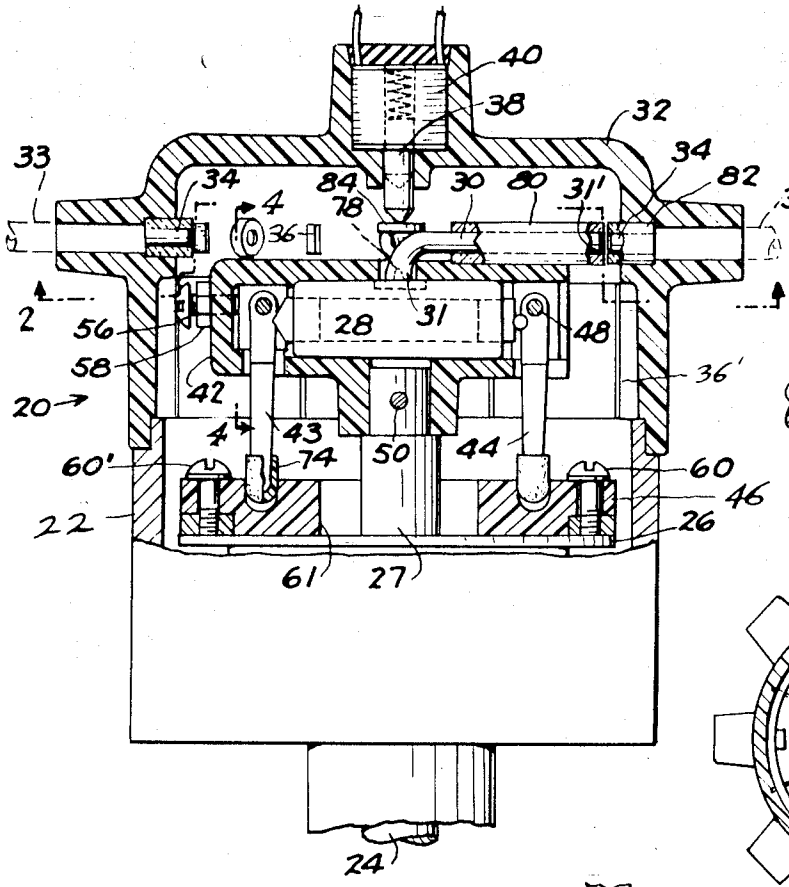


FIG. 1

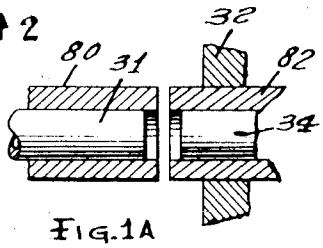


FIG. 1A

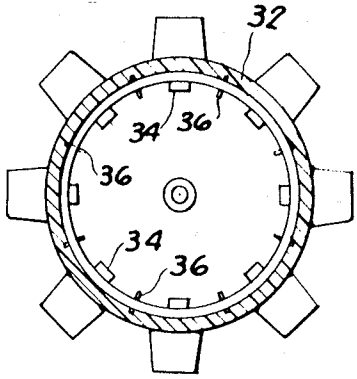


FIG. 2

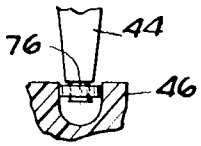


FIG. 6

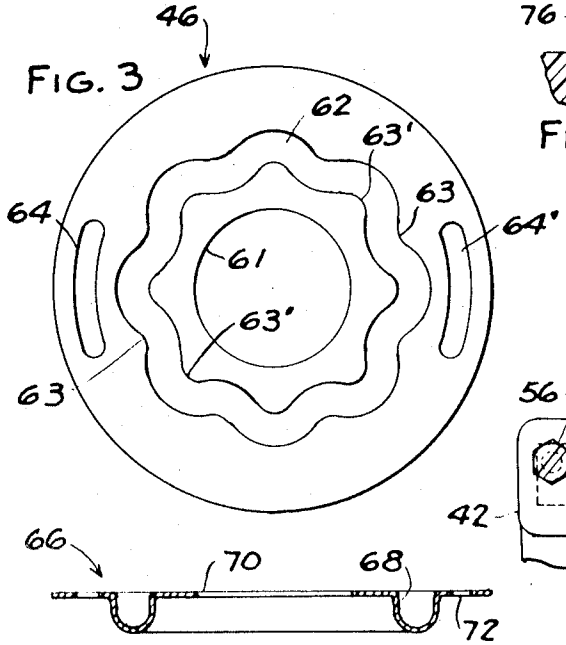


FIG. 3

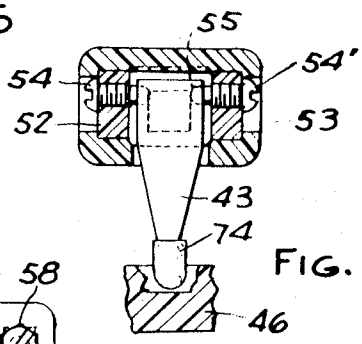


FIG. 4

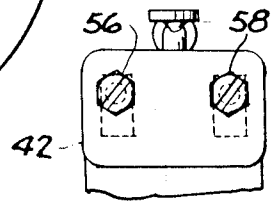


FIG. 5

FIG. 7

INVENTOR.
LAWRENCE E. HOOVER
BY
Barnes, Kisselle, Raisch & Choate
ATTORNEYS

PIEZOELECTRIC DISTRIBUTOR WITH IMPROVED CONTACT INSULATIVE SHIELDING STRUCTURE

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. 1A is a fragmentary view to enlarged scale of a portion of FIG. 1.

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.

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 piezoelectric 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 semispherical tip **74** of a wear resistant material with a low coefficient of friction, such as the flourocarbon 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 journaled 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. The spacing arrangement of electrodes **31** and **34** with their associated tubes is best shown in FIG. 1A. 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 deenergized.

In operation, when a set of diametrically opposed lobes **63** of cam plate **46** and **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 high potential which is then conducted through central electrode **30** to a terminal electrode **34** via the airgap 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 deenergizing 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 deenergized 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 resistance 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 an 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, and a plurality of stationary terminals of an electrically conductive material adapted to be electrically connected one to each of the spark plugs of the engine and being supported in said housing and having exposed portions therein arranged in a circular row, the improvement which comprises:

a. a distributor rotor carried by said shaft for rotation therewith and having a terminal,

b. a shield of an electrically insulative material circumscribing at least a portion of said terminal and extending beyond an exposed portion thereof positioned to pass sequentially in arc gap proximity to said exposed portions of said stationary terminals, and

c. A plurality of shields of an electrically insulative material, one circumscribing at least a portion of each of said stationary terminals and projecting beyond said exposed portion of its associated housing terminal in the direction of closest alignment of said rotor terminal and associated housing terminal when the same are juxtaposed in said arc gap proximity relationship, said rotor terminal shield and each of its associated stationary terminal shields having a mechanical clearance therebetween in said gap proximity relationship.

2. The apparatus as defined in claim 1 in which said shields each extend at least 0.005 inches beyond the end of its associated terminal.

3. The apparatus as defined in claim 1 in which said insulative material is heat-resistant electrically insulating glass.

4. 4. In an 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 operable to be rotatably driven by said engine and having one end extending through one of said end walls into said housing, and a plurality of stationary terminals of an electrically conductive material operable to be electrically connected one to each of the spark plugs of the engine and being supported in said housing and having exposed portions therein arranged in a circular row, the improvement which comprises:

a. a distributor rotor carried by said shaft for rotation therewith and having an elongated terminal,

b. a first sleeve of an electrically insulative material enclosing said terminal over a substantial portion of its length and extending beyond an exposed end portion thereof, said end portion positioned to pass sequentially in arc gap proximity to said exposed portions of said stationary terminals, and

c. a plurality of sleeves of electrically insulative material like sized to said first sleeve, each enclosing a different one of said stationary terminals and extending beyond its exposed end portion, said rotor terminal sleeve and each of said stationary terminal sleeves having a mechanical clearance therebetween during said arc gap proximity.

* * * * *