Sept. 13, 1955 J. R. HARKNESS 2,717,589

PIEZOELECTRIC IGNITER ELEMENT

Filed Aug. 18, 1953

Fig. 1.

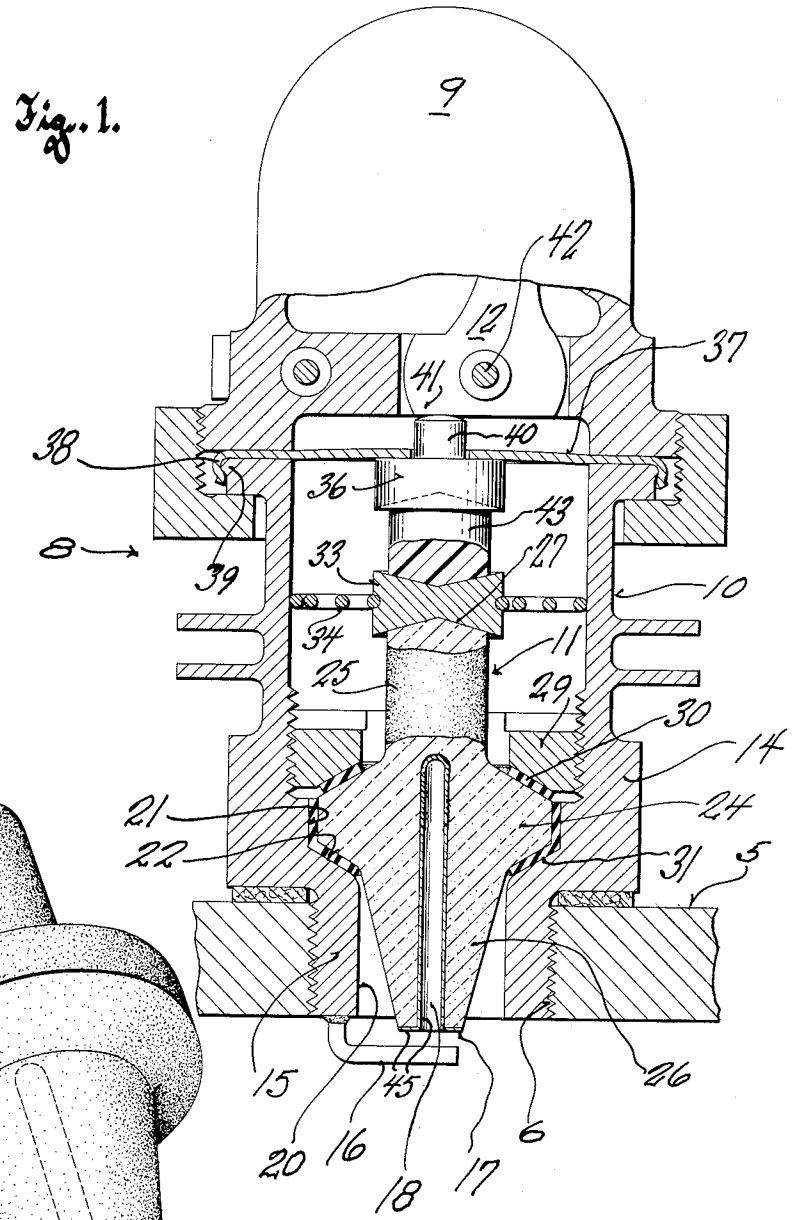
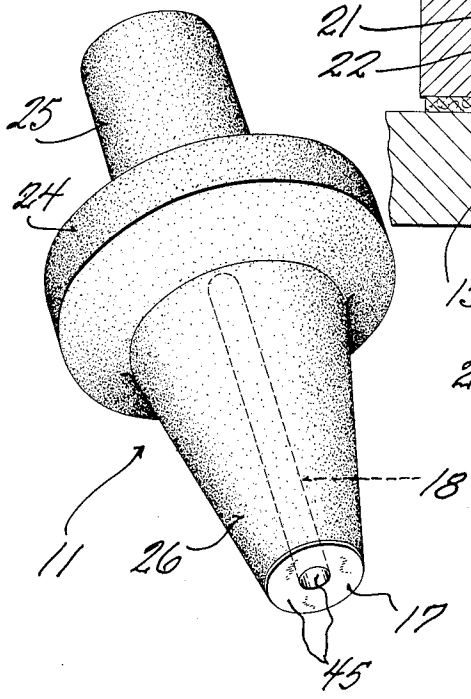


Fig. 2.



Inventor
Joseph R. Harkness
By Dr. Milton Jones
Attorney.

United States Patent Office 2,717,589
Patented Sept. 13, 1955

2,717,589

PIEZOELECTRIC IGNITER ELEMENT

Joseph R. Harkness, Milwaukee, Wis., assignor to Briggs & Stratton Corporation, Milwaukee, Wis., a corporation of Delaware

Application August 18, 1953, Serial No. 375,030

10 Claims. (Cl. 123—169)

This invention relates to igniters for internal combustion engines and refers more particularly to a piezoelectric igniter of the type basically disclosed and claimed in my copending application, Serial No. 301,830, filed July 31, 1952 (now Patent No. 2,649,488), and more specifically like that disclosed and claimed in my copending application, Serial No. 373,809, filed August 12, 1953. In these copending applications a polycrystalline piezoelectric element comprises the voltage source, and makes it possible to eliminate the conventional source of voltage, usually a battery-coil combination or a magneto.

As in the later filed of the aforesaid copending applications, the purpose of this invention is to provide a compact igniter unit which may be mounted upon the cylinder of an internal combustion engine in the same location as the conventional spark plug so that it not only closes the spark plug opening in the cylinder and provides the sparking electrodes but also contains the voltage source, and the means for mechanically stressing the piezoelectric element which provides this voltage source in timed relation to the engine operating cycle.

As brought out at length in my copending application, Serial No. 373,809, the igniter unit therein disclosed comprises a substantially tubular housing of electrically conductive material having a screw-threaded base at its lower end to fit the threaded spark plug port in the wall of the engine combustion chamber, and the piezoelectric element is mounted in an upright position inside the housing with its lower end seating upon a ceramic plug fixed inside the base of the housing and sealing the aperture in the base through which the center electrode of the igniter projects. This electrode, of course, extends upwardly through and is imbedded in the ceramic plug and its upper end is electrically connected with a metallic cup or seat in which the lower end of the piezoelectric element is received.

A similar seat fitting over the upper end of the piezoelectric element and electrically connected with the surrounding housing wall provides not only the upper terminal for the element but a surface upon which a blow may be struck to effect the mechanical stressing of the piezoelectric element necessary for the generation of a sparking voltage, thereby to cause a spark to jump from the exposed lower end of the center electrode to a cooperating grounded electrode fixed on the screw threaded base of the housing.

The present invention carries this concept of a unitary spark plug and voltage source still further and has as its purpose to simplify the construction to the extent that the ceramic plug is eliminated and the piezoelectric element itself is formed with a bulbous enlargement to seat upon an upwardly facing annular shoulder in the base of the housing not only to support the piezoelectric element in the housing, but also to seal the aperture in the base against the ingress of combustion gases into the interior of the housing when the igniter unit is in operation upon an engine cylinder.

More specifically it is an object of this invention to provide an improved piezoelectric cell, per se, for igniters of the character described, having an end portion which is adapted to be mechanically stressed for the generation of sparking voltage and having electrically conductive means therein leading from that portion of the piezoelectric element which is subjected to mechanical stress during operation of the igniter to the exterior of the other end of the element at which point it provides an electrode for cooperation with a companion electrode.

Still another object of this invention resides in the provision of an improved polycrystalline piezoelectric cell for an igniter of the character described which may be contained in an igniter housing considerably smaller than was possible heretofore, so as to effect a desirable reduction in size of the igniter unit.

With these and other objects in view, which will appear as the description proceeds, this invention resides in the novel construction, combination and arrangement of parts substantially as hereinafter described and more particularly defined by the appended claims, it being understood that such changes in the precise embodiment of the hereindisclosed invention may be made as come within the scope of the claims.

The accompanying drawing illustrates one complete example of the physical embodiment of the invention constructed according to the best mode so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a view principally in vertical section of the igniter of this invention, showing the same mounted on a portion of the wall of an engine cylinder; and

Figure 2 is a perspective view of the piezoelectric igniter cell, per se.

Referring now more particularly to the accompanying drawing in which like reference characters indicate like parts, the numeral **5** generally designates the wall of the combustion chamber of an internal combustion engine (not shown) on which the conventional spark plug is usually secured, a threaded hole **6** in the wall **5** being provided to receive the threaded base of the spark plug. The igniter unit of this invention, indicated generally by the numeral **8**, not only eliminates the need for the conventional magneto or battery-coil voltage source, but also supplants the conventional spark plug in the manner disclosed in my copending application Serial No. 373,809. The igniter unit comprises upper and lower housing sections **9** and **10**, respectively, detachably secured together in any convenient way; the lower housing section **10** containing the polycrystalline piezoelectric cell **11** of this invention and the upper housing section **9** containing the hammer **12** and actuating means therefor, not shown, for imposing an abrupt blow upon the piezoelectric cell to effect mechanical stressing of the same in the manner necessary to generate a sparking voltage therein.

The general details of the upper and lower housing sections and the manner in which they are secured together along with the hammer actuating mechanism, are specifically described in my copending application, Serial No. 373,809, and it is only necessary herein to point out that the lower housing section **10** is preferably of generally tubular shape and most conveniently mounted in an upright position on the cylinder wall **5**. For this purpose the lower end portion of the tubular housing section **10** provides a base **14** preferably of hexagonal shape to enable a wrench to be applied thereto, and a neck **15** projecting coaxially from the underside of the base has screw threads on its exterior to fit the screw threaded aperture **6** in the wall **5** of the engine combustion chamber.

Fixed to the extremity of the threaded neck **15** is the outer or grounded electrode **16** of the igniter unit, and this electrode may be directed radially inwardly toward

the axis of the housing, as shown, to be spaced a short distance beneath the center electrode 17 of the igniter unit, which in this case is carried by the piezoelectric cell in a manner to be described.

A hole 20 extending through the threaded neck 15 on the base coaxially of the tubular housing section 10 opens upwardly into a counterbore 21 in the base, which in turn communicates with the slightly larger diameter interior of the tubular housing section 10. The bottom of the counterbore thus provides an upwardly facing shoulder 22 and the surface of this shoulder preferably is frusto-conical, converging downwardly toward the axis of the hole 20 in the threaded neck of the base. This shoulder provides a seat upon which the enlarged medial portion 24 of the polycrystalline piezoelectric cell seats to receive support from the base of the housing. The cell further comprises an upwardly extending active portion 25 integral with the body, and a lower portion 26 extending downwardly through the hole 20 in the threaded neck of the base.

From the description thus far it will be apparent that the polycrystalline piezoelectric cell of this invention comprises a more or less bulbous intermediate or body portion, and smaller diameter end portions projecting coaxially from opposite sides of the body portion.

The reduced upper end portion 25 of the cell may be cylindrical, as shown, and preferably terminates in a convex or conical end surface 27 facing upwardly toward the top of the housing section 10. The lower end portion 26 is preferably taperingly reduced toward its extremity, so as to be frusto-conical, and preferably terminates in a flat surface, at its lower extremity, substantially normal to the axis of the cell. The enlarged intermediate portion 24 of the cell generally constitutes an annular flange encircling the cell medially of its ends. Preferably, this flange is of substantially frusto-conical cross section with its downwardly facing surface matching the slope of the shoulder 22 at the bottom of the counterbore in the base and its upwardly facing surface sloping in the opposite direction.

A retaining nut 29 threaded into the interior of the base and bearing upon the upwardly facing surface of the flange-like enlarged body portion of the cell holds the cell firmly in position in the housing, coaxially thereof, with the enlarged body portion of the cell seating upon the shoulder 22 at the bottom of counterbore 21 and thus sealing the hole 20 in the base. A gasket 30 interposed between the retaining nut 29 and the upwardly facing surface of the enlarged medial portion of the cell and a similar gasket 31 interposed between the bottom of the counterbore 22 and the downwardly facing surface of the flange-like enlarged body portion of the cell may be provided to effect the best possible gas-tight seal between the engine combustion chamber and the interior of the housing for the piezoelectric cell. The lower gasket 31 may also extend upwardly around the periphery of the flange-like body portion of the cell, as illustrated.

The piezoelectric cell is mechanically stressed in timed relation with the engine operating cycle by the same means disclosed in my copending application, Serial No. 373,809. This means includes a metallic cap or seat 33 fitting over the upper end of the piezoelectric element and electrically connected with the surrounding housing wall as by a compressed spiral spring 34 having its inner convolution tightly embracing the periphery of the cap and its outer convolution urged into good electrical contact with the wall of the housing. Similarly, an anvil 36 is held upon the cap 33 by a spring metal cover 37 closing the top of the lower housing section and secured thereto by a downwardly curled edge 38 on the periphery of the cover either snapped or curled over a bead 39 on the exterior of the housing at the top thereof.

The anvil has a reduced striker portion 40 extending upwardly through a central hole in the cover 37 for cooperation with the toe 41 of the hammer, so that abrupt release of the hammer in response to the force built up in the torsion bar 42 upon which the hammer is mounted causes a sharp blow to be struck upon the striker 40 and conducted downwardly upon the cap 33 through a slightly resilient cushioning block 43 of plastic or other suitable material.

This sudden impact upon the anvil, of course, is transmitted to the piezoelectric cell to mechanically stress that portion thereof lying between the convex extremity of the cylindrical upper end portion 25 of the cell and the underside of the enlarged medial portion or body 24 of the cell. The impact thus imposed upon the upper portion of the cell creates therein a sparking voltage which is conducted to the center electrode 17 by an electrical conductor 18 and causes a spark to jump across the gap between the two electrodes, it being understood that the grounded electrode 16 is electrically connected to the upper extremity of the cell.

It is important that the conductor 18 extend upwardly through the lower end portion 26 of the piezoelectric cell far enough to reach the portion of the cell which is mechanically stressed during operation. Accordingly, as shown, the conductor 18 extends substantially to the bottom of the upper end portion 25 of the cell. The lower end portion 26 of the cell is not subjected to the mechanical stress which results from the hammer blow imposed upon the striker 40, and serves mainly as an insulator for the center electrode to eliminate the need for the conventional ceramic plug such as was employed in my aforesaid copending application, Serial No. 373,809.

While the center electrode 17 and the conductor 18 may be readily comprised of a length of suitable wire imbedded in the lower end portion 26 of the cell, it is one of the features of this invention that the center electrode and its conductor may be provided by a silver coating 45 on the wall of a relatively small diameter bore in the cell, opening to its bottom and having its inner end reaching the portion of the cell which is stressed mechanically by the imposition of the hammer blow upon the upper end of the cell. The silver coating preferably, also covers the flat extremity of the lower end portion of the cell to increase the area of the center electrode.

Another highly important feature which results from the provision of the polycrystalline piezoelectric cell of this invention is that it makes possible a substantial reduction in the height of the lower housing section 10. This, of course, is desirable from the standpoint of economy of materials and space required for the igniter unit of this invention.

From the foregoing description, taken together with the accompanying drawing it will be readily apparent to those skilled in the art that this invention provides an igniter unit featuring a polycrystalline piezoelectric element of improved design, which is not only capable of generating the necessary sparking voltage in consequence of mechanical stressing of the cell but which is also formed to seal the opening in the base of the housing in which the cell is mounted, and in addition has the center electrode formed as a part thereof.

What I claim as my invention is:

1. An igniter element, comprising: a polycrystalline piezoelectric cell; spaced abutments on said piezoelectric cell providing surfaces on the exterior of the cell facing in opposite directions and against which force may be applied to the cell to effect mechanical stressing of a portion of the cell; and electrically conductive means in said cell reaching from said portion of the cell to an external surface thereof at which point said conductive means is exposed to provide an electrode for the igniter element.

2. The igniter element set forth in claim 1 wherein said electrically conductive means is provided by a coating of conductive material on the wall surfaces of a hole extending into the interior of the cell with the mouth

of the hole opening to the exterior of the cell at which point said means provides the electrode and with the bottom of the hole reaching the portion of the cell which is stressed by forces applied to said oppositely facing surfaces on the cell.

3. The igniter element set forth in claim 2 further characterized by the fact that the surface of the cell surrounding the mouth of the hole is coated with electrically conductive material so as to increase the area of the electrode provided by the exposed portion of said electrically conductive means.

4. An igniter element, comprising: an elongated polycrystalline piezoelectric cell; spaced abutments on said piezoelectric cell providing surfaces on the exterior of the cell facing in opposite directions and against which force may be applied to the cell to effect mechanical stressing of that portion of the cell between said surfaces, one of said surfaces being at one end of the cell, and the abutment having the other of said surfaces thereon being located intermediate the ends of the cell; and electrically conductive means in the cell reaching from said portion of the cell to the other end of the cell at which point the electrically conductive means is exposed to provide an electrode for the igniter element.

5. An igniter element comprising: a polycrystalline piezoelectric cell having an enlarged body portion and having reduced end portions projecting in opposite directions from said body portion; and electrically conductive means in the cell extending from the extremity of one end portion of the cell into the interior of the body portion of the cell.

6. The igniter element set forth in claim 5 wherein said electrically conductive means is provided by a coating of conductive material on the wall surfaces of a hole extending into the interior of the cell with the mouth of the hole opening to the extremity of said end portion of the cell at which point said means is exposed to provide said electrode and with the bottom of the hole reaching the interior of the body portion of the cell.

7. The igniter element set forth in claim 6 further characterized by the fact that the extremity of the end portion of the cell surrounding the mouth of the hole is coated with electrically conductive material so as to increase the area of the electrode provided by the exposed portion of said electrically conductive means.

8. An igniter element, comprising: an elongated polycrystalline piezoelectric cell having a substantially cylindrical upper end portion, a lower end portion, and an enlarged medial portion integral with said end portions and comprising an annular flange on the exterior of the cell having surfaces facing in opposite directions lengthwise of the axis of the cell; and electrically conductive means extending axially through said lower end portion of the cell from the lower extremity thereof into the enlarged medial portion of the cell, the exposed lower end of said electrically conductive means providing an electrode for cooperation with another electrode.

9. In a piezoelectric igniter: a housing including an electrically conductive mounting base having a bore opening to the exterior of the housing and a counterbore communicating said bore with the interior of the housing, the bottom of said counterbore defining an annular seat having a surface facing in the direction of the interior of the housing; a polycrystalline piezoelectric cell having an enlarged annular medial portion supported upon said seat, and having reduced end portions projecting in opposite directions from said medial portion substantially coaxially thereof, one of said end portions of the cell extending into the bore of the base toward the exterior of the housing and the other end portion thereof extending into the interior of the housing and terminating in a surface facing in the same direction as said seat; retaining means connected between the housing and the annular medial portion of the cell for firmly holding said annular medial portion of the cell upon its seat to thus seal the bore in the base; and electrically conductive means in said first designated end portion of the cell and extending from the interior of the annular medial portion of the cell to the extremity of said first designated end portion of the cell at which point said electrically conductive means provides an electrode for the igniter.

10. In a piezoelectric igniter: a housing having an opening therein centrally of and leading to an annular shoulder in the interior of the housing; an electrode on the exterior of the housing adjacent to the mouth of said opening therein; an elongated polycrystalline piezoelectric cell fixed in the housing with a medial portion of the cell closing said opening in the housing, one end portion of the cell projecting in one direction from said medial portion thereof into the interior of the housing, and the other end portion of the cell projecting in the opposite direction from said medial portion thereof into said opening in the housing toward the mouth thereof; electrically conductive means connecting the extremity of said first designated end of the cell with said electrode; and other electrically conductive means in said cell extending from said medial portion of the cell through the second designated end portion of the cell to the extremity thereof, at which point said other electrically conductive means is exposed to provide an electrode for cooperation with said other electrode.

References Cited in the file of this patent

UNITED STATES PATENTS

1,200,663	Smith	Oct. 10, 1916
1,512,319	Stuver	Oct. 21, 1924
2,068,744	Gutzke	Jan. 26, 1937
2,190,713	Hintze	Feb. 20, 1940