Sept. 13, 1955 J. R. HARKNESS 2,717,916

PIEZOELECTRIC IGNITER FOR INTERNAL COMBUSTION ENGINES

Filed Aug. 12, 1953 3 Sheets-Sheet 1

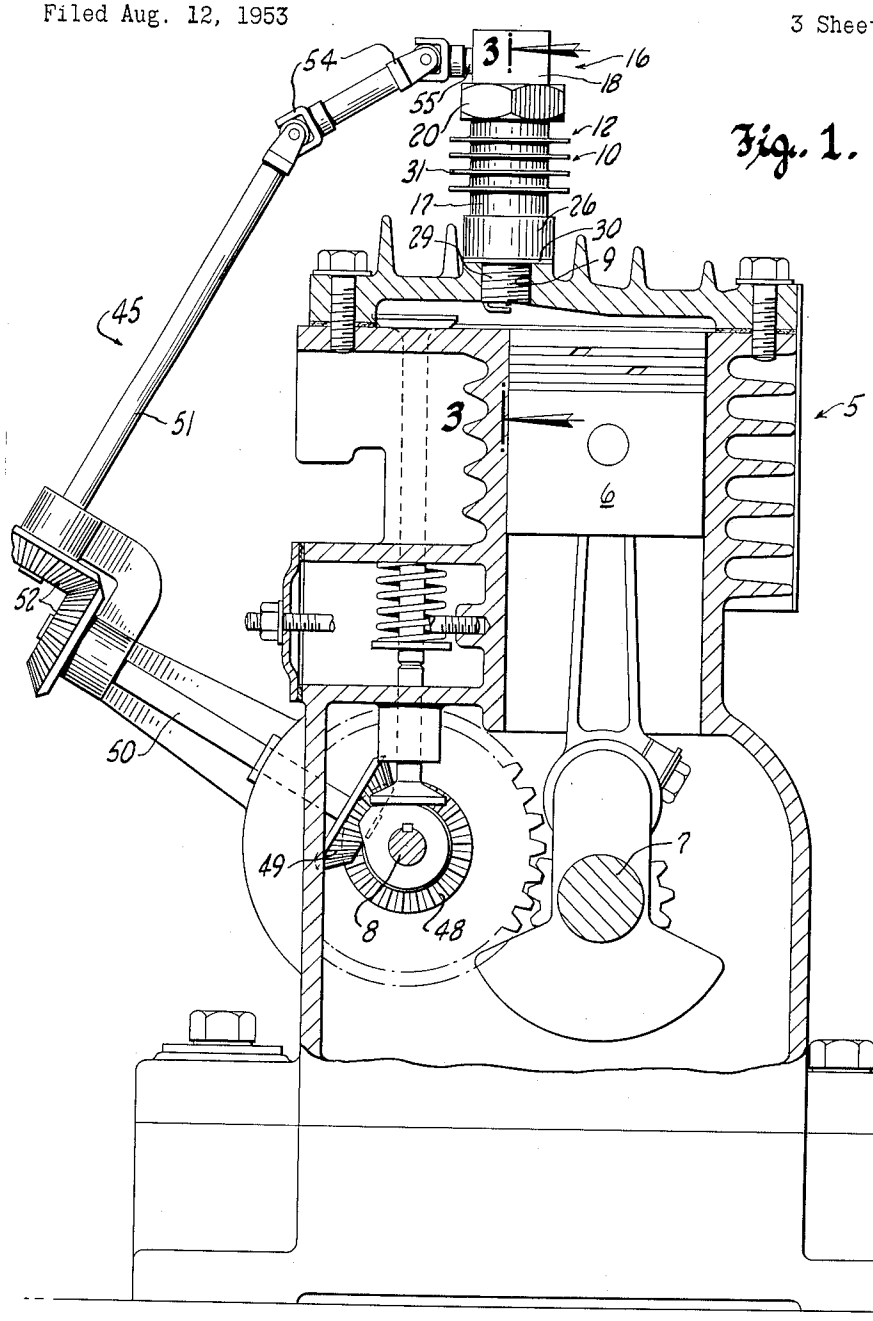



Fig. 1.

Inventor
Joseph R. Harkness
By Dan Smith Jones
Attorney

Sept. 13, 1955 J. R. HARKNESS 2,717,916

PIEZOELECTRIC IGNITER FOR INTERNAL COMBUSTION ENGINES

Filed Aug. 12, 1953 3 Sheets-Sheet 2

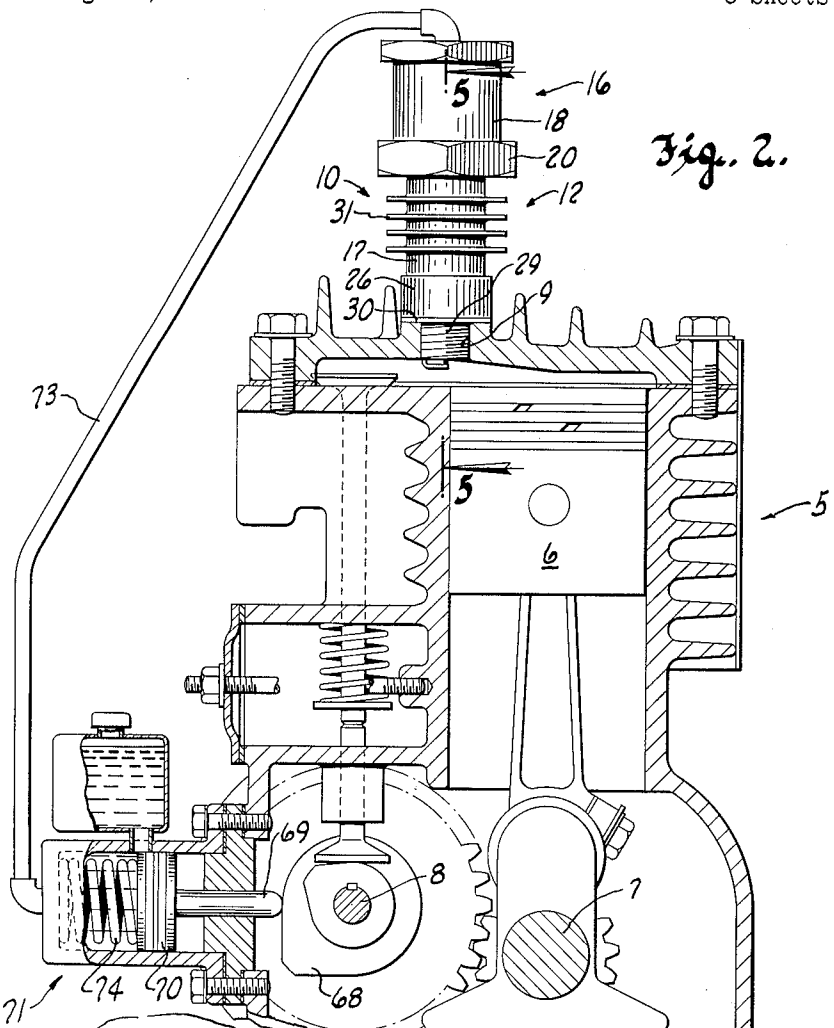



Fig. 2.

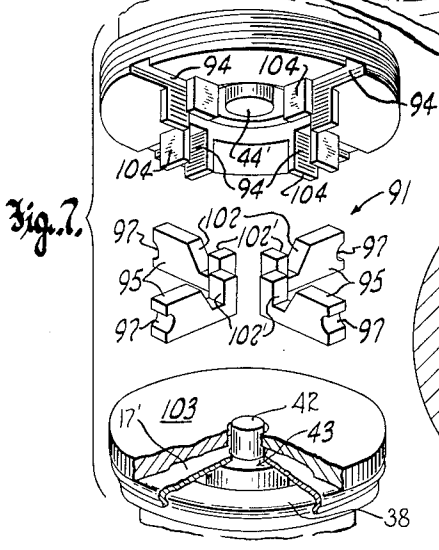



Fig. 7.

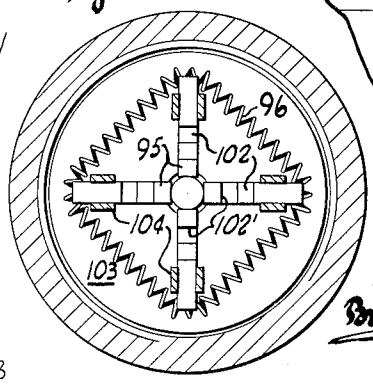



Fig. 8.

Inventor
Joseph R. Harkness
By Dewitt Jones
Attorney

Sept. 13, 1955 J. R. HARKNESS 2,717,916

PIEZOELECTRIC IGNITER FOR INTERNAL COMBUSTION ENGINES

Filed Aug. 12, 1953 3 Sheets-Sheet 3

Fig. 3.

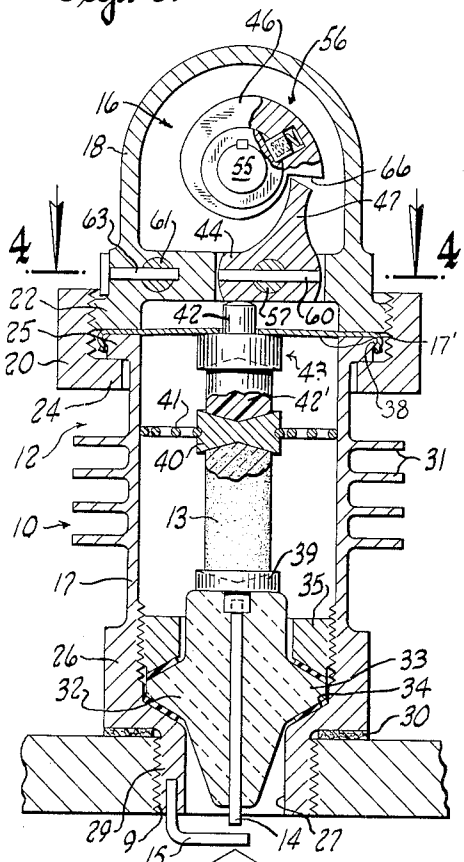



Fig. 4.

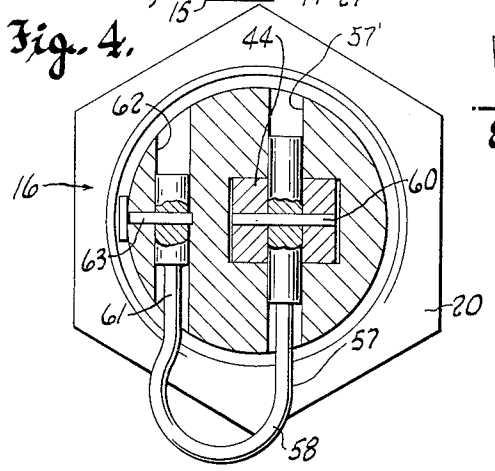



Fig. 5.

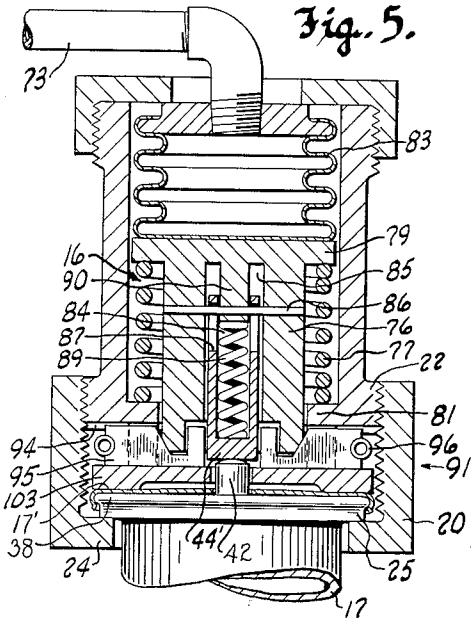
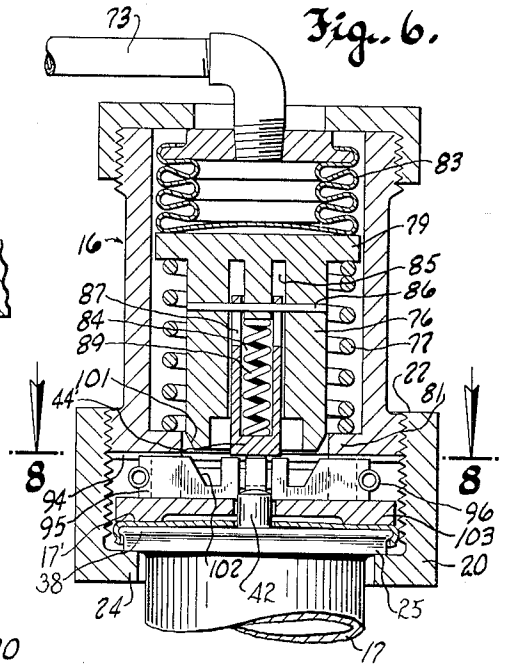



Fig. 6.




Inventor
Joseph R. Harkness
By Dashiell Hamilton Jones
Attorney

United States Patent Office 2,717,916
Patented Sept. 13, 1955



2,717,916

# PIEZOELECTRIC IGNITER FOR INTERNAL COMBUSTION ENGINES

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

Application August 12, 1953, Serial No. 373,809

14 Claims. (Cl. 123—148)

This invention relates to igniters for internal combustion engines, and refers more particularly to an igniter of the type disclosed and claimed in my copending application, Serial No. 301,830 (now Patent No. 2,649,488), filed July 31, 1952, in which the voltage source for the igniter comprises a polycrystalline piezoelectric element.

In general, my aforesaid copending application discloses that a polycrystalline piezoelectric element, such as polycrystalline metallic titanate mixed with a ceramic binder and vitrified into a solid ceramic body, is capable of generating a sufficiently high voltage for satisfactory, commercially reliable spark plug firing when abruptly mechanically stressed; and, moreover, that a piezoelectric element of such composition is capable of withstanding the high mechanical stresses imposed upon it in that service.

In the ignition system of that application the polycrystalline piezoelectric element was provided and employed only as a substitute for the conventional battery energized coil or magneto voltage source for an ignition system, and a conventional spark plug was used as an igniter for the engine. The present invention makes possible not only the elimination of the conventional battery or magneto energized ignition voltage source but also elimination of the need for a conventional spark plug. Hence the present invention provides a basically new type of igniter, which replaces the conventional voltage source and spark plug with a single compact unit wherein the sparking electrodes and the voltage source are housed together and occupy only slightly more space than the conventional spark plug. The present invention thus takes full advantage of certain outstanding features of a polycrystalline piezoelectric element voltage source as disclosed in my aforesaid copending application.

It is, accordingly, an object of the present invention to provide a highly compact igniter unit for an internal combustion engine, employing a polycrystalline piezoelectric element, which igniter may be mounted on the cylinder of an engine in substantially the same location as the conventional spark plug, occupying at most, only slightly more space than the conventional spark plug, but embodying both the sparking electrodes, the piezoelectric voltage source, and the means for mechanically stressing the piezoelectric element in timed relation to the engine operating cycle.

From the foregoing stated object of the invention, it will be apparent that it is another object of the present invention to make possible the elimination of a source of ignition voltage of an internal combustion engine which is separate and apart from the spark plug.

Another object of this invention resides in the provision of an igniter mechanism of the character described wherein the piezoelectric element is mounted directly adjacent to the sparking electrodes, to eliminate the need for external ignition wiring on an internal combustion engine, and wherein mechanical stressing of the piezoelectric element is effected by means of a hammer which may be



actuated either hydraulically or mechanically from the engine crankshaft.

In connection with the foregoing object, it is another object of this invention to provide a compact mechanical actuator for the hammer which mechanically stresses the piezoelectric element to generate ignition voltage. It is also an object of this invention to provide a compact hydraulic actuator for the hammer, which actuator may be employed as an alternative to the mechanical actuating mechanism just mentioned.

Still another object of this invention resides in the provision of an igniter unit of the character described which may be readily assembled and disassembled, so that it is inexpensive to manufacture and simple to repair.

With the above 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 drawings illustrate two complete examples of the physical embodiments of the invention constructed according to the best modes so far devised for the practical application of the principles thereof, and in which:

Figure 1 is a view, principally in vertical section, of a single cylinder engine having the igniter of this invention installed thereon;

Figure 2 is a similar view showing different means for stressing the piezoelectric element of the igniter;

Figure 3 is an enlarged fragmentary sectional view taken on the plane of the line **3—3** in Figure 1;

Figure 4 is a cross-sectional view taken on the plane of the line **4—4** in Figure 3;

Figure 5 is an enlarged fragmentary sectional view taken on the plane of the line **5—5** in Figure 2;

Figure 6 is a view similar to Figure 5 but showing the hammer retracted;

Figure 7 is an exploded perspective view of the elements of the hammer latch mechanism of the Figure 2 embodiment of the invention; and

Figure 8 is a cross-sectional view taken on the plane of the line **8—8** in Figure 6.

Referring now more particularly to the accompanying drawings in which like numerals designate like parts throughout the several views, the numeral 5 designates generally the cylinder of a conventional internal combustion engine (in this case shown as a small single-cylinder gasoline engine) in which a piston **6** is reciprocable to drive a rotatable crankshaft **7**.

Ordinarily, ignition for an engine of this type is supplied by means of a spark plug screwed into a threaded port **9** in the cylinder head and having electrodes projecting into the interior of the cylinder, the spark plug being connected with a source of ignition voltage such as a spark coil or magneto by means of a wire extending from the spark plug to the voltage source. The igniter **10** of the instant invention, however, comprises a compact, substantially self-contained unit which may be screwed into the same threaded port **9** in which the base of the conventional spark plug is ordinarily received, and which, moreover, embodies an ignition voltage source as well as the sparking electrodes, although, as may be seen from Figures 1 and 2, it is only slightly larger in size than a conventional spark plug.

In general, the igniter of this invention comprises a housing **12** which encloses and forms a supporting structure for the device, a piezoelectric element **13** mounted within the housing, a pair of electrodes **14** and **15** projecting from the housing into the interior of the engine com-

bustion chamber, and mechanism, designated generally by 16, in the upper portion of the housing, for imparting timed mechanical stresses to the piezoelectric element.

The housing, in each embodiment of the invention, comprises a conductive, generally tubular lower housing member 17 which encloses and supports the piezoelectric element and carries the electrodes, and an upper housing member 18 which encloses the mechanism for mechanically stressing the piezoelectric element. These two housing members are readily detachably secured together by means of a flanged nut 20 which screws onto a threaded lower portion 22 on the upper housing member and which has its radially inwardly extending flange 24 engaged under an annular flange 25 at the top of the lower housing member. At its lower end, the housing member 17 terminates in a base portion 26 having a bore 27 therethrough opening to the interior of the housing. The base portion has a reduced diameter neck 29 on its bottom preferably threaded to fit the standard spark plug port 9 in the cylinder head. The joint between the cylinder head wall and the base of the igniter housing is sealed by a more or less conventional gasket 30.

Cooling fins 31 on the exterior of the lower housing member dissipate heat from the cylinder head away from the piezoelectric element, and it will be observed that the tubular wall of the lower housing member has a substantially larger diameter than the piezoelectric element, so that the housing wall is radially spaced from the piezoelectric element all the way around the latter. The lower housing member is closed adjacent to the base 26 by a core or plug 32 which may be formed of an insulative ceramic material like that customarily employed to carry the center electrode of the conventional spark plug. One of the two electrodes 14 of the igniter extends through the plug and projects downwardly therefrom, centrally of the bore 27 and into the interior of the combustion chamber. The plug is readily removably secured in the lower housing member by reason of the fact that it has a bulged, flange-like medial portion 33 which is clamped between an annular upwardly facing shoulder 34 in the base and a retaining ring 35 threaded into the interior of the base. Gaskets between the shoulder 34 and the plug portion 33, and between the retaining ring 35 and the plug portion 33, insure against leakage of combustion gases into the interior of the igniter housing.

The piezoelectric element 13 may be in the form of an elongated cylinder, as shown, and its lower end is seated in a conductive seat or pressure plate 39 secured to the top of the plug. The seat 39 is electrically joined with the upper end portion of the electrode 14, and thus provides one of the terminals for the piezoelectric element.

An upper conductive seat or pressure plate 40 fitting over the upper end of the piezoelectric element provides the other terminal for the element, and cooperates with the lower seat 39 to properly mount the piezoelectric element on the plug 32. The upper seat 40 is supported in the housing and electrically connected therewith by means of a radially compressed spiral spring 41, the inner coil of which encircles and is secured to the upper seat and the outer coil of which is engaged with the tubular wall of the lower housing member under substantial pressure. This manner of mounting the upper pressure plate enables blows from the stressing mechanism 16 to be transmitted to the piezoelectric element through the pressure plate 40. Since the electrode 15 is secured directly to the base of the housing, it is thereby electrically connected with the upper end of the piezoelectric element, and the exposed lower ends of the two electrodes thus cooperate to define a spark gap in the combustion chamber across which a spark can jump in consequence of mechanical stressing of the piezoelectric element.

Resting on the top of the upper seat 40 is an anvil or striker 43 which receives the blows from a hammer 44 comprising a part of the actuating mechanism 16. The anvil preferably is of two-part construction, having a



hardened metal upper portion 42 and a firm but slightly resilient lower cushion portion 42' of plastic or the like interposed between the top portion and the upper seat 40.

It is important to note that the lower housing member 17 is closed at its top, independently of the upper housing member 18, by a flexible metallic disc 17' confined between the two housing members, and secured to the lower housing member as by a depending flange 38 on the disc either spun or snapped over a bead on the periphery of the flange 25. The disc has a central aperture therein through which the reduced upper portion 42 of the anvil 43 projects to hold the anvil properly engaged on the upper seat 40. The disc 17' also bears against the upwardly facing shoulder on the anvil at the base of its reduced upper portion 42, under a degree of pressure, so that by the engagement of the anvil with the upper seat 40, assurance is had that the piezoelectric element will be tightly clamped between the upper and lower seats 40 and 39, respectively.

Because of the disc 17', the upper housing member may be removed from the lower housing member at any time, without danger of the parts in the interior of the lower housing member becoming displaced out of their proper positions.

Another highly important advantage of completely enclosing the lower housing member is that it affords a natural grounded and conductive shield around the piezoelectric element and its terminals, or in other words, the complete ignition system, to preclude such electrical radiation as might otherwise interfere with radio reception.

The structure described up to this point is identical in each of the embodiments of the invention shown in the drawings, and the two versions differ from one another in respect to the manner in which they provide for actuation of a hammer to effect mechanical stressing of the piezoelectric element in timed relation to the engine cycle. In the Figure 1 embodiment, actuation of the hammer is effected by means of a mechanical motion transmission comprising a universal shaft, designated generally by 45, an actuating cam 46 rotatably driven by the universal shaft, and a cam follower 47 on the hammer. The universal shaft is driven from a drive gear 48 on the engine cam shaft 8 which meshes with a driven gear 49 on a lower shaft element 50 projecting outwardly from the crankcase of the engine. An upper shaft element 51 is rotatably driven from the lower shaft element by means of meshing bevel gears 52 on the two shaft elements, and the upper shaft element includes universal joint connections 54 which enable the shaft to transmit rotation to a camshaft 53 in the igniter actuating mechanism without interference from the cylinder head or other engine structure. The cam 46 is rotatably mounted on the shaft 53 and is constrained to rotate therewith in one direction (counterclockwise as shown in Figure 3) by means of a unidirectional clutch connection indicated generally at 56, which prevents damage of the hammer actuating mechanism as a result of rotation of the cam in the opposite direction when the shaft is inadvertently rotated the wrong way in consequence of a backfire, for example.

The hammer 44 is generally boot-shaped and is mounted for rocking motion in directions to carry its toe to and from striking engagement with the top portion 42 of the anvil or striker. The hammer is mounted for such rocking motion on one leg 57 of a U-shaped torsion spring 58, the leg 57 being rotatable in a lateral bore 57' in the upper housing member. The hammer is non-rotatably secured to said leg of the spring as by means of a transverse pin 60, while the other leg 61 of the torsion spring is non-rotatably but readily removably secured in a lateral bore 62 in the upper housing member as by means of a pin 63. The manner in which the hammer is mounted on the spring causes the hammer to be normally biased in a direction to carry its toe portion

downwardly toward striking engagement with the top of the anvil.

The "upper" 47 of the boot-shaped hammer comprises the cam follower previously mentioned, and which cooperates with the actuating cam 46 to rock the hammer in timed relation with the engine cycle. Attention is directed to the fact that the actuating cam 46 has an abrupt step thereon, as at 66. As the actuating cam rotates in a counterclockwise direction, as shown in Figure 3, the cam follower portion of the hammer, following the gradual rise in the cam surface, will raise the toe of the hammer against the bias of the torsion spring, loading the spring, but at the proper instant in the engine cycle for firing the charge in the cylinder the abrupt step on the actuating cam will pass the cam follower and the hammer will therefore be released to respond to the force stored in the torsion spring, and its toe portion will be propelled sharply down onto the striker to effect the necessary mechanical stressing of the piezoelectric element. As the actuating cam continues to rotate, the hammer will of course be raised for the next firing cycle.

In the embodiment of the invention shown in Figure 2 and illustrated in greater detail in Figures 5 and 6, the hammer 44' is actuated by hydraulic mechanism. As in the Figure 1 embodiment of the invention, the hammer actuating mechanism is indirectly operated from the engine crankshaft and thus functions in timed relation with the engine cycle. In this version of the invention the engine cam shaft has a cam 68 which engages a cam follower 69 that serves as the actuator for the piston 70 of a hydraulic piston pump 71. At the proper point in the cycle of engine operation for ignition of the charge in the cylinder, the cam 68 on the engine cam shaft impels the piston of the hydraulic pump in a direction to effect the pressure stroke of the pump, forcing hydraulic fluid to flow through a hydraulic duct 73 which communicates the outlet of the pump with the actuating mechanism in the igniter housing. A spring 74 in the piston pump, reacting between the top of the pump cylinder and the piston thereof, effects the return stroke of the pump and biases the cam follower into continuous engagement with the cam 68 on the engine cam shaft.

A hydraulic ram 76 is reciprocable up and down in the upper housing member and is biased upwardly by means of a return spring 77 encircling the ram and having one end engaged under an annular flange 79 at the top of the ram and its other end seating on a radially inwardly projecting annular flange 81 at the bottom of the upper housing member. On the pressure stroke of the pump 71 the ram is hydraulically forced downwardly against the bias of this spring, as by means of a bellows-type diaphragm 83 having its interior communicated with the outlet of the hydraulic duct 73.

In this embodiment of the invention the hammer 44' is cylindrical but has an upwardly opening well 84 and is mounted in a downwardly opening coaxial well 85 in the ram. The hammer has a lost motion connection with the ram provided by a transverse pin 86 extending across the well in the ram and through vertically elongated slots 87 in the cylindrical wall of the hammer. Seated in the upwardly opening well 84 in the hammer is a strong compression spring 89 which reacts between the bottom of said well 84 and an abutment 90 on the ram and thus biases the hammer downwardly with respect to the ram. It will be seen that as the ram is propelled downwardly in response to expansion of the diaphragm the hammer would tend to descend with the ram. However, downward motion of the hammer is blocked, to effect a substantial compression of the spring 89, by means of a latch mechanism designated generally by 91 and now about to be described. This latch mechanism releases the hammer when the ram reaches a predetermined point in its descent, to cause the hammer to descend abruptly onto the anvil in response to the compressive energy stored in the spring 89.

As best seen in Figure 7, the underside of the bottom wall of the upper housing member has a plurality of radially extending slots 94 therein in each of which an elongated latch element 95 is endwise slidably mounted, resting on a centrally apertured disc 103 confined between the two housing members. Downwardly extending spacer lugs 104 on the bottom wall of the top housing member engage the disc to assure sufficient space, when the retaining nut 20 is fastened, to provide sliding clearance between the disc and the bottom of the slots in which the latch elements slide.

A garter spring 96 embracing the latch elements biases them radially inwardly, and it will be observed that the outer end of each latch element is grooved, as at 97 to retain the garter spring against displacement out of engagement with the latch elements. When the ram and the hammer are elevated, as in Figure 6, the garter spring holds the latch elements drawn inwardly, in latching positions in which their inner end portions block descent of the hammer and hold it spaced above the striker.

Withdrawal of the latch elements from their latching positions of engagement with the hammer is effected by means of cooperating cam surfaces 101 and 102 on the bottom of the ram and on each latch element, respectively, the cam surfaces on the latch elements being defined by the upwardly converging outer side wall of an upwardly opening notch 102' near the radially inner end of each latch element. As the ram descends, its upwardly diverging cam surface 101 engages the cam surface on each latch element to cam the latter radially outwardly and thus carry its inner end portion away from the hammer, thus releasing the hammer with an abrupt, trigger-like action whereby it strikes the anvil with a forcible blow which effects the necessary mechanical stressing of the piezoelectric element.

As the piston 70 of the piston pump recedes in response to its return spring, releasing pressure in the diaphragm, the ram will likewise be raised in response to its return spring 77, forcing hydraulic fluid out of the diaphragm and back through the hydraulic duct 73 to the piston pump. As the ram is raised, the pin 86 engages the top of the slots 87 in the cylindrical wall of the hammer, raising the hammer; and it will be seen that when the ram and hammer are raised to the position shown in Figure 6 the latch elements are returned to their latching positions by the garter spring, where they block descent of the hammer in readiness for the next cycle of operation.

The latching position of the latch elements is defined by engagement of their ends with the reduced upper end 42 of the striker or anvil which projects upwardly through the central aperture in the disc 17' and through the aperture in the disc 103, above the top surface of the latter, where it is exposed to the blow of the hammer. The diameter of the upper portion of the anvil is sufficiently less than that of the hammer so that the latch elements may be retracted a distance far enough to enable their inner end portions to normally obstruct descent of the hammer.

From the foregoing description, taken together with the accompanying drawings, it will be apparent that this invention provides a basically new type of igniter, embodying in a unitary compact housing both the igniter electrodes and a source of ignition voltage.

What I claim as my invention is:

1. An igniter comprising: a conductive igniter body having a base for mounting the igniter on an engine cylinder; a pair of electrodes carried by the body and projecting from the base in a position to be located inside a cylinder upon which the body is mounted to provide a spark gap inside the cylinder, one of said electrodes being elec-

trically grounded to the body and the other being electrically insulated therefrom; a polycrystalline piezoelectric element; means mounting said element on the body with a portion thereof electrically insulated from the body but electrically connected to the ungrounded electrode and with another portion thereof grounded to the body; and means carried by said body for mechanically stressing the polycrystalline piezoelectric element.

2. An igniter for an engine having a combustion chamber, said igniter comprising: an upright conductive body for the igniter having an apertured base at its lower portion by which the igniter may be mounted on a wall of the combustion chamber; an insulator carried by said body in the lower portion thereof and sealing the aperture in the base; an ungrounded electrode mounted in the insulator with one end projecting downwardly therefrom in line with the aperture in the base and exposed at the bottom of the base; a grounded electrode on the bottom of the base cooperating with the exposed portion of the ungrounded electrode to define a spark gap therewith; a polycrystalline piezoelectric element; a conductive seat carried by said insulator and with which one part of the piezoelectric element is engaged, said seat being electrically connected with said ungrounded electrode; a second conductive seat engaged with another part of the piezoelectric element and electrically connected with the body; said seats cooperating to support the piezoelectric element on the body; and means for periodically applying abrupt mechanical stresses to the element.

3. An igniter for a combustion engine comprising: an igniter body having an electrically conductive base at its lower end for mounting the igniter on a wall of an engine chamber; a pair of spaced apart conductive seats carried by the body above the base, one of said seats being electrically connected with the base and the other being electrically insulated from the base; a polycrystalline piezoelectric element engaged between and supported by said seats; an electrode electrically connected with said insulated seat and having an end portion exposed at the bottom of the base; an electrode grounded on the base cooperating with the exposed end portion of the other electrode to define a spark gap; and means on the body for imposing abrupt mechanical stresses upon said piezoelectric element.

4. A unitary igniter for a combustion engine, comprising: an electrically conductive base; a pair of electrodes fixed with respect to the base, one of said electrodes being insulated from the base and the other electrode being electrically connected with the base, and said electrodes having adjoining exposed portions defining a spark gap; a polycrystalline piezoelectric element carried by the base in fixed relation thereto and electrically connected between the other end portions of the electrodes; and means carried by the base to provide for imposing an abrupt mechanical stress onto the piezoelectric element.

5. An igniter for an engine having a combustion chamber, said igniter comprising: an upright conductive body for the igniter having an apertured base at its lower portion by which the igniter may be mounted on a wall of the combustion chamber; an insulator carried by said body in the lower portion thereof and sealing the aperture in the base; an ungrounded electrode mounted in the insulator with one end projecting downwardly therefrom in line with the aperture in the base and exposed at the bottom of the base; a grounded electrode on the bottom of the base cooperating with the exposed portion of the ungrounded electrode to define a spark gap therewith; a polycrystalline piezoelectric element; means mounting the piezoelectric element on the top of the insulator with a portion of the piezoelectric element electrically connected with said ungrounded electrode, said means including a conductive seat engaged with another part of the piezoelectric element and electrically connected with the body; and means for periodically applying abrupt mechanical stresses to the element.

6. The igniter of claim 5 further characterized by the fact that said seat is spaced above the top of the insulator; and further characterized by the fact that said means for applying abrupt mechanical stresses to the piezoelectric element is located above said seat and acts thereon to apply stresses to the piezoelectric element.

7. In an igniter of the character described: an upright insulative core; an electrode extending downwardly through the core with its lower end portion projecting from the bottom of the core for cooperation with another electrode; a conductive seat fixed on the top of the core in electrical connection with another portion of said electrode; a polycrystalline piezoelectric element mounted on said seat and projecting upwardly therefrom; and means cooperating with said seat to hold the piezoelectric element in place on the top of the core, comprising a conductive cap-like terminal fitting over the top of the piezoelectric element, and having an upwardly facing surface upon which abrupt mechanical blows may be imposed and through which terminal the force of such blows may be imparted to the piezoelectric element to mechanically stress the same, said terminal providing for the electrical connection of the piezoelectric element with said other electrode.

8. In an igniter of the character described: an upright insulative core; an electrode extending downwardly through the core with its lower end portion projecting from the bottom of the core for cooperation with another electrode; a polycrystalline piezoelectric element; and means mounting the piezoelectric element on the top of the core, said means comprising a lower terminal fixed on the upper portion of the core in electrical connection with another portion of said electrode and providing a seat in which the lower end of the piezoelectric element is received, and an upper terminal engaged over the top of the piezoelectric element and providing a pressure plate having an upwardly facing surface upon which abrupt mechanical blows may be imposed and through which such blows may be transmitted to the piezoelectric element to mechanically stress the same, said upper terminal providing for electrical connection of the piezoelectric element with said other electrode.

9. An igniter for an internal combustion engine having a piston reciprocable in a cylinder to rotatably drive a crankshaft, said igniter comprising: a polycrystalline piezoelectric element; a conductive housing, the lower end portion of which provides a base projecting into a port in the cylinder wall to mount the igniter on the cylinder; an insulative plug in said base; means on said plug defining a fixed seat in the housing insulated from the walls of the housing and in which one end of the piezoelectric element is held; an electrode extending through said plug with its upper end electrically connected with said seat and its lower end portion projecting into the engine cylinder; a second electrode electrically connected with the base of the housing and projecting into the engine cylinder and cooperating with the first-named electrode to define a spark gap; a second seat in the housing cooperable with said fixed seat to hold the piezoelectric element on said plug, said second seat being electrically connected with the tubular wall of the housing; and impact mechanism driven from the crankshaft of the engine and cooperable with said second seat for periodically imparting sudden mechanical blows upon the piezoelectric element through said second seat to mechanically stress the piezoelectric element and cause it to generate a sparking voltage across said electrodes.

10. The igniter of claim 9, wherein said impact mechanism comprises a hammer mounted in the housing for motion toward and from said second seat and for imposing abrupt blows upon said second seat; and hammer actuating mechanism operatively connected with the crankshaft and the hammer for imparting such blows to said second seat at a predetermined point in each cycle of engine operation.

11. In a reciprocating internal combustion engine having a piezoelectric type igniter contained in a housing mounted on a wall of the combustion chamber of the engine, means for periodically imparting sudden mechanical blows to the piezoelectric element in timed relation to the rotation of the crankshaft, said means comprising: a hammer mounted on the housing of the igniter for motion toward and from the piezoelectric element; a rotatable cam in said housing and supported thereby, said cam having an abrupt step on its cam surface; a driving connection between the cam and the engine crankshaft; spring means yieldingly biasing the hammer toward the piezoelectric element; and a cam follower on said hammer, cooperable with the cam, whereby the hammer is drawn away from the piezoelectric element during a portion of the rotational cycle of the cam to load said spring means and the hammer is released and impelled into engagement with the piezoelectric element by said spring means when said abrupt step in the cam passes the cam follower.

12. In a reciprocating internal combustion engine having a piezoelectric type igniter contained in a housing mounted on a wall of the combustion chamber of the engine, means for periodically imparting sudden mechanical blows to the piezoelectric element in timed relation to the rotation of the crankshaft, said means comprising: a hammer mounted on the housing of the igniter for motion toward and from the piezoelectric element; a hydraulic ram in said housing constrained to reciprocation toward and from a predetermined position; a spring reacting between said hydraulic ram and the hammer to bias the hammer toward the piezoelectric element in consequence of motion of the hydraulic ram toward said position; latch means in the housing for precluding movement of the hammer toward the piezoelectric element in response to the bias of said spring; cooperating cam means on the latch means and the hydraulic ram for releasing said latch means in consequence of motion of the hydraulic ram to said predetermined position, to thereby release the hammer and permit it to be suddenly impelled toward the piezoelectric element in response to bias force stored in said spring; and means for varying the pressure of hydraulic fluid supplied to said hydraulic ram in accordance with the rotational position of the engine crankshaft.



13. An igniter unit comprising: an electrically conductive housing including side walls, and a base at the lower end of the housing providing for securement of the housing to a wall of an engine combustion chamber; an electrode exposed at the bottom of the base and electrically grounded thereto; a polycrystalline piezoelectric element fixed inside the housing with a lower portion thereof seating upon the base and electrically insulated therefrom; means defining an electrode electrically connected with the lower portion of the piezoelectric element and projecting downwardly through the base in electrically insulated relation thereto for cooperation with said grounded electrode to provide a spark gap therewith; means on an upper portion of the piezoelectric element through which a blow may be imposed upon the piezoelectric element to mechanically stress the same, said means including a terminal electrically connecting the piezoelectric element with the housing, and a striker seated upon said terminal; and a resilient metal cover secured over the top of the housing and bearing upon said striker under pressure to hold the striker and the terminal properly seated upon the piezoelectric element, said cover cooperating with the housing to completely enclose the voltage source provided by the piezoelectric element and thus act as a conductive grounded shield for the igniter unit when it is mounted on the wall of an engine combustion chamber.

14. The igniter unit set forth in claim 13 wherein said disc-like cover has a central aperture therein; and further characterized by the provision of an upwardly extending reduced portion on the striker projecting through said aperture in the cover to receive the blow by which the piezoelectric element is mechanically stressed, the engagement of said reduced portion on the striker in the cover aperture assuring against lateral motion of the striker relative to the piezoelectric element.

**References Cited** in the file of this patent

UNITED STATES PATENTS

| | | |
|---|---|---|
| 2,068,744 | Gutzke | Jan. 26, 1937 |
| 2,190,713 | Hintze | Feb. 20, 1940 |
| 2,649,488 | Harkness | Aug. 18, 1953 |