United States Patent [19]

Heinouchi et al.

[11] **3,729,639**

[45] **Apr. 24, 1973**

[54] **PIEZOELECTRIC IGNITER**

[75] Inventors: **Yosiaki Heinouchi,** Otokuni-gun, Kyoto-fu; **Keizo Tabuchi,** Kyoto-fu; **Tetsuo Tatsumi,** Otokuni-gun, Kyoto-fu, all of Japan

[73] Assignee: **Murata Manufacturing Co., Ltd.,** Kyoto-fu, Japan

[22] Filed: **Mar. 27, 1972**

[21] Appl. No.: **238,137**

[30] **Foreign Application Priority Data**

Ap. 2, 1971 Japan 46/20523
Aug. 22, 1971 Japan 46/64136

[52] **U.S. Cl.**.....**310/8.3,** 310/8.7, 317/DIG. 11, 317/81

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

[58] **Field of Search**.....310/8.3, 8.7, 9.1, 310/9.4; 317/79 PZ, 81, DIG. 11

[56] **References Cited**

UNITED STATES PATENTS

3,466,474	9/1969	Ochiai	310/8.7
3,475,654	10/1969	Ochiai et al.	310/8.7 X
3,509,388	4/1970	Mifune et al.	310/8.7
3,541,360	11/1970	Tonari	310/8.7

Primary Examiner—J. D. Miller
Assistant Examiner—Mark O. Budd
Attorney—Thomas Cifelli, Jr. et al.

[57] **ABSTRACT**

A piezoelectric igniter comprising a piezoelectric element, an enclosure fixedly accommodating the piezoelectric element, an operating body movable in relation to the enclosure and a piezoelement impacting mechanism including a striker operatively accommodated in the operating body and mounted with two split ring springs each formed respectively with a pair of end pins, the impacting mechanism being operable so as to inwardly grip each pair of the end pins thereby permitting the striker to strike against the piezoelectric element in accordance with the movement of the operating body in relation to the enclosure.

8 Claims, 10 Drawing Figures

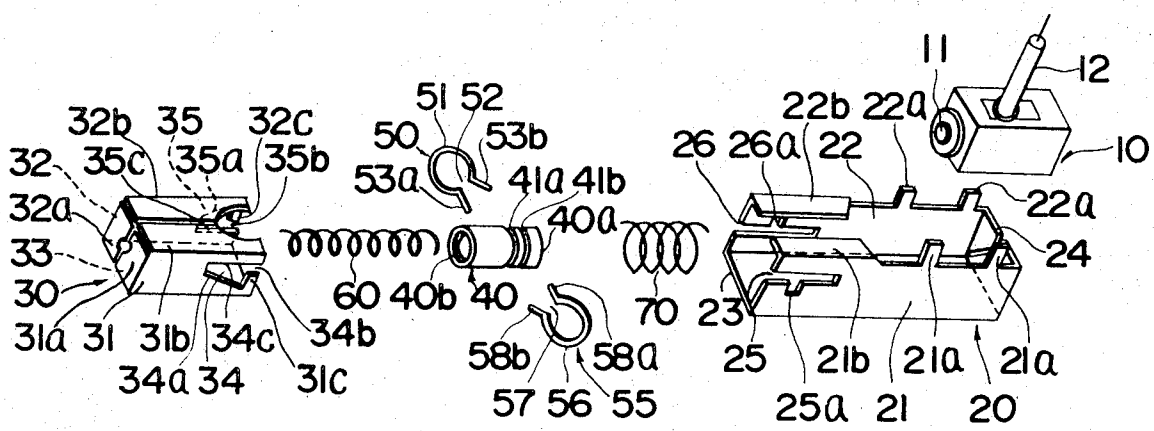


FIG. 1

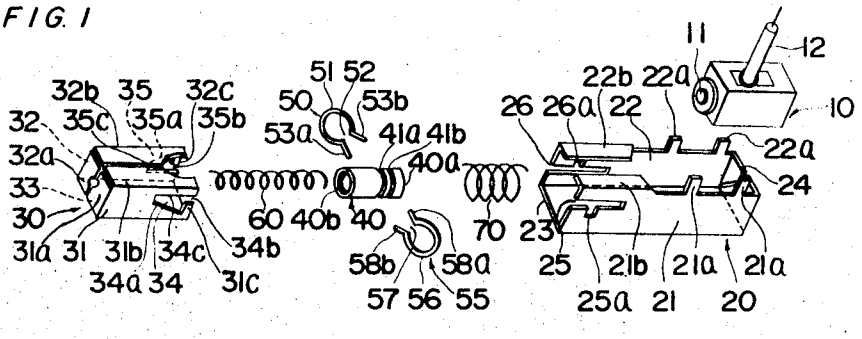


FIG. 2

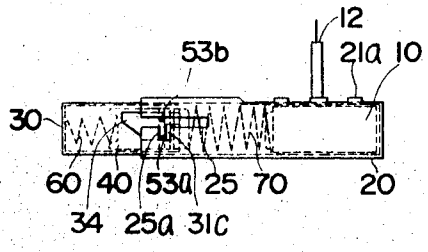


FIG. 3

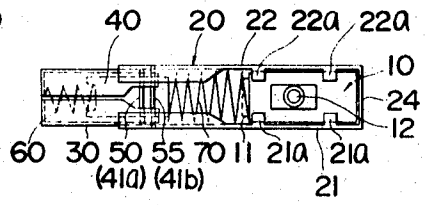


FIG. 4

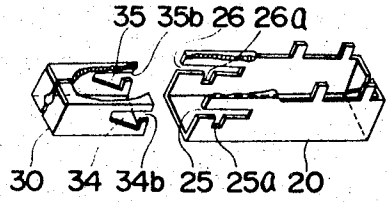


FIG. 5

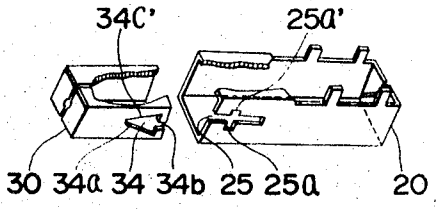


FIG. 6

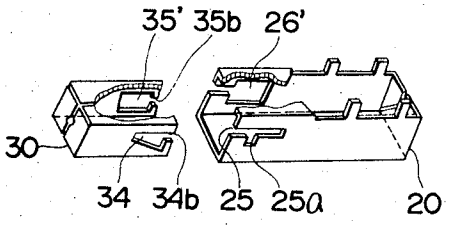


FIG. 7

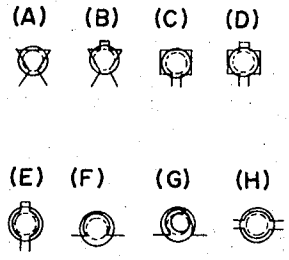


FIG. 8

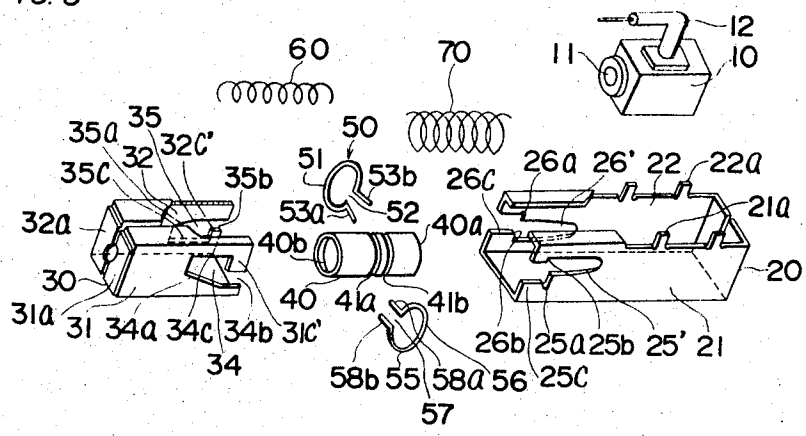


FIG. 9

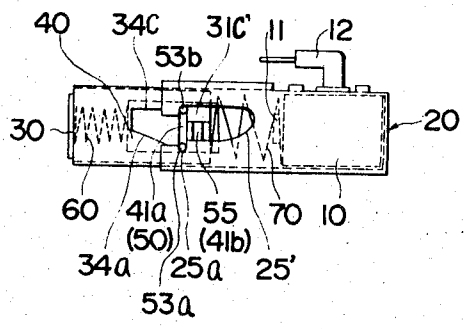
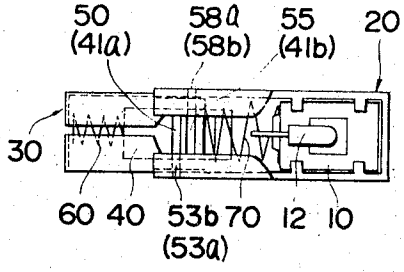


FIG. 10



PIEZOELECTRIC IGNITER

The present invention relates to an igniter of a type employing a piezoelectric element for generating a high voltage spark across a spark gap.

In presently known piezoelectric igniters, the impact transmitted to a piezoelectric element causes a change in the mechanical stress which effects the discharge of a high voltage spark across a spark gap. The spark thus produced by the impact is of short duration and, unless the impact transmitted to the piezoelectric element is otherwise of a relatively great value, it does not always suffice to insure ignition of certain types of gaseous fuels, for example, city gas, butane, natural gas and/or others which are generally considered hard-to-ignite gases.

Heretofore, various kinds of crystals capable of exhibiting the piezoelectric effect have been found. However, the piezoelectric element comprised of any one or combination of these crystals must receive sufficient impact or pressure to generate a high voltage spark capable of insuring the ignition of any one or combination of the hard-to-ignite gaseous fuels.

In view of the foregoing, various types of impacting mechanisms for giving an impact to the piezoelectric element have been proposed. Of them, one exemplary type of impacting mechanism particularly intended for use in a cigarette lighter or like small and compact devices is disclosed in the U.S. Pat. No. 3,509,388, patented on Apr. 28, 1970.

According to this Patent, the piezoelectric impacting mechanism essentially comprises a striker operatively accommodated in an operating body for giving an impact to a piezoelectric element fixedly accommodated in an enclosure into which said operating body can be collapsibly engaged. In this prior art device, a spring used to accumulate the energy necessary for the striker to strike against the piezoelectric element is concurrently used to apply a rotational force to the striker. The application of this rotational force to the striker is necessitated to firmly engage the striker in a position away from the piezoelectric element by the engagement between a stopper rod, which is formed in said striker and extending at right angles to the axis of the striker, and an engagement notch formed in the operating body or the enclosure. With this rotational force imparted to the striker by the spring, the stopper rod is engaged to the depth of the engagement notch and, as the operating body is moved a substantial distance toward the piezoelectric element, the stopper rod is released from the engagement notch accompanying a rotation of the striker about its own axis against the biasing direction of the spring and, subsequently, the striker is rapidly moved by the action of the same spring to strike against the piezoelectric element. On the other hand, when the operating body is returned to the initial position after the impact has been given to the piezoelectric element in the manner as hereinbefore described, the striker is automatically rotated by the action of the spring, thereby causing the stopper rod to firmly engage to the depth of the engagement notch formed in either or both of the operating body and the enclosure.

The prior art device of the above construction functions satisfactorily. However, manufacture thereof is very complicated because the striker must be applied

not only with an axial pushing force necessary to enable the striker to strike against the piezoelectric element, but also with a rotational force to bias the striker in one predetermined direction about its own axis thereby to permit the energy required for a sufficient impact to be accumulated while the striker in maintained at a position away from the piezoelectric element. Especially, in view of the fact that the application of the rotational force to the striker is inevitable, the spring employed for the dual purpose as hereinbefore described must be interposed in the torsioned state in such a way as to have one end rigidly connected with a portion of the operating body and the other end rigidly connected with one end of the striker. It is, in fact, difficult and requires experienced skill to establish the torsioned state of the spring of small size in a limited space such as furnished by the igniter for use in a cigarette lighter, resulting in increased manufacturing costs.

In addition, because of the spring thus torsioned, the operating body, of substantially square cross-section, which is slidably accommodated in the enclosure of the same cross-section is compelled to be placed in offset relation with respect to the enclosure about the axis of the striker and, hence, there is constant contact between the operating body and the enclosure at their corresponding corner portions. This means that, during the use of the igniter of the above construction, the constant sliding contact between the corner portions of the operating body and the enclosure leads to increased wear of material and then to a substantial reduction of the durability of the piezoelectric igniter.

Accordingly, an essential object of the present invention is to provide an improved piezoelectric igniter wherein the above mentioned disadvantages inherent in the conventional igniter of a similar character can be substantially eliminated to facilitate the manufacture thereof at low cost with improvement in the durability.

Another important object of the present invention is to provide an improved piezoelectric igniter which can be easily assembled, and disassembled if desired for replacement of the eventually deteriorated piezoelectric element, without requiring any experienced skill.

A further object of the present invention is to provide an improved piezoelectric igniter which exhibits a reliable performance with a reasonable amount of finger pressure.

A still further object of the present invention is to provide an improved piezoelectric igniter of compact size with a simplified structure wherein a smooth and accurate operation can be ensured.

According to the present invention, the piezoelectric igniter proposed in preferred embodiments generally comprises an enclosure accommodating therein a piezoelectric element or crystal of any known type; an operating body capable of moving in relation to the enclosure; a striker or hammer slidable in the direction of the axis of the enclosure between an engaged position and a released position in accordance with the movement of the operating body in relation to the enclosure for giving a sufficient impact to the piezoelectric element and provided on its periphery with a pair of suitably spaced grooves into which split ring springs each having a pair of integral end pins extending radially outwardly therefrom are elastically engaged; a first compression spring for applying an axial pushing force

to said striker and concurrently for accumulating the necessary energy to enable the striker to strike against the piezoelectric element upon release of the accumulated energy; a second compression spring which may be omitted, or, if desired, used for facilitating a return movement of the operating body accompanying the return of the striker from the released position to the engaged position; and means formed in the operating body for gripping the end pins inwardly so that said striker is released from the engaged position thereby permitting said striker to rapidly move against the piezoelectric element.

One essential feature of the present invention resides in the employment of the split ring springs and the concurrent use of the gripping arrangement. It may be possibly said that the pair of the end pins of each of the split ring springs herein employed corresponds, in function, to the stopper rod employed in the aforesaid prior art device of a similar character. While in the prior art device a procedure of securing the stopper rod to the striker is complicated because the spring for applying the axial pushing force to the striker must be essentially torsioned in the assembled condition to enable the stopper rod to act as a component for maintaining the striker at the engaged position away from the piezoelectric element. However, in the present invention, each of the split ring springs can be easily, and in fact with no difficulty, mounted on the striker in such a way as to elastically insert the split ring spring into the corresponding groove formed on the periphery of the striker. Because of the particular dimensional relationship between the split ring springs and the grooves on the striker, the use of the split ring springs does not creat any obstacles on the peripheral surface of the striker so that a smooth movement of the striker in the axial direction within the operating body and/or the enclosure toward the piezoelectric element can be advantageously ensured with no substantial reduction of the speed of travel of said striker between the engaged position and the released position.

Furthermore, according to the present invention, partly because of the above mentioned feature, the piezoelectric igniter can be advantageously manufactured at a reduced cost of approximately one-half of the manufacturing cost of the conventional device of a similar character. The remaining reason therefor is because the particular design of the gripping arrangement according to the present invention facilitates the accommodation of either the operating body or the enclosure in relation to the other while the striker is operatively suspended therein through the pair of the end pins of each of the split ring springs.

In any event, these and other objects and features of the present invention will become apparent from the following description thereof taken in conjunction with preferred embodiments with reference to the accompanying drawings, in which;

FIG. 1 is an exploded view of a piezoelectric igniter in one preferred embodiment of the present invention,

FIG. 2 is a side view of the piezoelectric igniter of FIG. 1 in the assembled condition,

FIG. 3 is a top plan view of the piezoelectric igniter of FIG. 1 in the assembled condition,

FIGS. 4 through 6 are perspective view of a combination of an operating body and an enclosure, each showing various types of gripping arrangement applicable in the piezoelectric igniter of the present invention,

FIG. 7 is a schematic diagram showing various types of spring element applicable in the piezoelectric igniter of the present invention,

FIG. 8 is an exploded view of the piezoelectric igniter in another preferred embodiment of the present invention,

FIG. 9 is a side view of the piezoelectric igniter of FIG. 8 in the assembled condition, and

FIG. 10 is a top plan view of the piezoelectric igniter of FIG. 8 in the assembled condition.

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the several views of the accompanying drawings.

Referring first to FIGS. 1 through 3, the piezoelectric igniter in one preferred embodiment of the present invention broadly includes a piezoelectric element **10** (hereinafter referred to as "piezoelement") of any known type and having an impact receiving area **11** and a high voltage lead **12**, an enclosure **20** of substantially square cross-section, an operating body **30** of the same cross-section as that of the enclosure **20** and a striker or hammer **40**.

Attention is first directed to the striker **40** which is of cylindrical shape and formed on its periphery with a pair of suitably spaced grooves **41***a* and **41***b* into which the corresponding number of split ring springs **50** and **55** are respectively elastically engaged. This cylindrical striker **40** has one end formed into a piezoelement striking area **40***a* and the other end preferably recessed to form a recessed end **40***b* for steadily receiving a compression spring **60** without permitting the spring **60** to displace from the axial alignment with the striker **40**, said compression spring **60** being disposed between the depth of the operating body **30** and the recessed end **40***b* of the striker **40** for applying an axial pushing force to said striker **40**.

As clearly shown in FIG. 1, each of the split ring springs **50** and **55** is preferably made of piano wire and shaped into the substantially Ω (omega) form. In other words, each of said split ring springs **50** and **55** has a substantially circular portion **51** or **56**, a pair of split ends of said circular portion **51** or **56** forming a gap **52** or **57** of the size as will be mentioned later, and a pair of end pins **53***a* and **53***b* or **58***a* and **58***b* integrally extending from the split ends of the circular portion **51** or **56** in the radially outward direction.

The preferable dimensional relationship between each of the split ring springs **50** and **55** and the striker **40** is such that the outer diameter of the circular portion **51** or **56** of the split ring spring in its initial state in which condition no force is applied thereto is substantially equal to or somewhat smaller than the diameter of the cylindrical striker **40** while the inner diameter of said circular portion of the split ring spring in its compressed state, in which condition said spring is radially inwardly compressed with the end pins **53***a* and **53***b* or **58***a* and **58***b* closing toward each other, is substantially equal to or somewhat greater than the diameter of the grooved portion of the striker **40**. In addition, the distance between the split ends or the spacing of the gap **52** or **57** is preferably smaller than the diameter of the grooved portion of the striker **40**, so that no even-

tual detachment of the split ring springs 50 and 55 from the grooves 41a and 41b and, hence, the striker 40, take place. Furthermore, the angle of segmential opening, formed between the end pins 53*a* and 53*b* or 58*a* and 58*b* of each pair at the imaginary intersecting point of the axial directions of said end pins of each pair, which may exist on the axis of symmetry of the split ring spring 50 or 55, is preferably about 45° by the reason as will be mentioned later.

The enclosure 20 is formed with a pair of opposed side plates 21 and 22, a bottom plate 23 and a depth plate 24, said side plates 21 and 22 being provided along their respective upper free edge with two pair of nail members 21*a* and 22*a* for securing the piezoelement 10 within the closure 20 in such a manner as substantially shown in FIGS. 2 and 3, and also with covering members 21*b* and 22*b* folded at right angles with respect to each other for slidably receiving the operating body 30 in place as clearly shown in FIG. 3.

Each of said side plates 21 and 22 is formed with a guide groove 25 or 26 having an engagement notch 25*a* or 26*a*, the grooves 25 and 26 with their respective engagement notches 25*a* and 26*a* being arranged in inverted relation with respect to each other as clearly shown in FIG. 1.

The operating body 30 is formed with a pair of opposed side plates 31 and 32 and a bottom plate 33, individual lateral portions 31*a* and 32*a* and upper portions 31*b* and 32*b* of the side plates 31 and 32 being respectively folded at right angles with respect to each other so that the operating body 30 in its finished appearance represents the substantially rectangular box-like shape. Each of the side plates 31 and 32 is provided with an opening of substantially right-angled triangular shape, as generally indicated by 34 and 35, said opening 34 or 35 having a slant edge 34*a* or 35*a*, a cut-out portion 34*b* or 35*b* and a guide edge 34*c* or 35*c* extending in parallel relation to the plane of the bottom plate 33, said cut-out portion 34*b* or 35*b* being defined by said guide edge 34*c* or 35*c* and a restricting member 31*c* or 32*c* which is a portion of the lateral end extremity of the side plate 31 or 32.

In any event, both the enclosure 20 and the operating body 30 of the above respective constructions can be easily fabricated by means of any known fabricating method such as press work.

When it comes to assemblage of the piezoelectric igniter with the above mentioned various components according to the present invention, the provision of the cut-out portions 34*b* and 35*b* on the both side plates 31 and 32 facilitates an insertion of the striker 40, mounted with the split ring springs 50 and 55 in the manner as hereinbefore described, into the operating body 30 with the compression spring 60 situated between the depth of the operating body and the recessed end 40*b* of the striker. In other words, what is necessary to insert the striker 40 into the operating body 30 is to inwardly grip the pairs of the end pins 53*a*, 53*b* and 58*a*, 58*b* of the split ring springs 50 and 55 thereby to bring said split ring springs 50 and 55 in the respectively compressed state and then let the gripped end pins of said pairs of the split ring springs on the striker 40 pass through the respective cut-out portions 34*b* and 35*b* while the compression spring 60 is at this time somewhat compressed. In this connection, it must be taken into consideration that the positionings of the openings 34 and 35 on the side plates 31 and 32 are relatively displaced with respect to each other in view of the presence of an interval between the split ring springs 50 and 55, namely, the grooves 41*a* and 41*b* on the striker 40. Similar considerations apply with respect to the positionings of the engagement notches 25*a* and 26*b* on the side plates 21 and 22 of the enclosure 20.

The operating body 30 thus mounted with the striker 40 is then inserted into the enclosure 20 in the substantially same manner as executed in the insertion of the striker having the split ring springs into the operating body. In other words, this can be achieved by inwardly gripping the two pairs of the end pins 53*a*, 53*b* and 58*a*, 58*b*, which have extended through the respective openings 34 and 35 incident to the insertion of the striker 40 into the operating body 30 as hereinbefore described, and then letting the gripped end pins of said pairs pass through the respective guide grooves 25 and 26, so that each one of said end pins can be elastically engaged in the corresponding engagement notch formed along each guide groove 25 or 26. In other words, the end pin 53*a* of the split ring spring 50 is engaged in the engagement notch 25a while the end pin 58*a* of the split ring spring 55 is engaged in the engagement notch 26*a*.

At this time, a return spring 70, of the inner diameter sufficient to render one end of said return spring 70 to be engaged to the open end extremity of the operating body 30 and the other end thereof to create no hindrance to the impact receiving area 11 of the piezoelement 10 must be interposed between the open end extremity of the operating body 30 and the piezoelement 10 within the enclosure 20. Despite of the provision of the return spring 70 normally acting to urge the operating body 30 in the direction away from the piezoelement 10, no separation of the operating body 30 in relation to the enclosure 20 will take place, once each one of said end pins 53*a* and 58*a* of said pairs has been elastically engaged in the corresponding engagement notches 25*a* and 26*a* of the respective guide grooves 25 and 26.

While in the construction as hereinbefore described, if the finger pressure is applied to the closed end of the operating body 30 causing the latter to move in relation to the enclosure 20 against the return spring 70 while the striker 40 is in the engaged position in which condition the end pins 53*a* and 58*a* are respectively engaged in the engagement notches 25*a* and 26*a*, the spring 60 is compressed to accumulate the energy necessary to cause the striker 40 to strike against the piezoelement 10. As the operating body 30 is further moved in relation to the enclosure 20, the slant edges 34*a* and 35*a* on the both side plates 31 and 32 commence to disengage the end pins 53*a* and 58*a* of the split ring springs 50 and 55 respectively from the engagement notches 25*a* and 26*a* and, upon this disengagement, the energy thus accumulated by the compression spring 60 can be suddenly released thereby causing the striker 40 to rapidly move toward the piezoelement 40 while the pairs of the end pins 53*a*, 53*b* and 58*a*, 58*b* of the split ring springs 50 and 55 in their gripped state are respectively guided along the guide grooves 25 and 26 to the depth of the latter. At this time, the impact receiving area 11 of the

piezoelement 10 receives a strong impact so that a high voltage spark can be generated across a spark gap between the high voltage lead 12 and a ground electrode which is not shown, but may be the enclosure 20 if it is made of metal.

Release of the finger pressure that has been applied to the closed end of the operating body 30 results in an automatic return of the striker 40 from the released position to the engaged position by the action of the return spring 70, accompanying a return movement of the operating body 30 to the initial position. It is to be noted that, when the striker 40 reaches the engaged position in the manner as hereinbefore described, the end pins 53*a* and 58*a* of the ring springs 50 and 55 respectively collapse into the engagement notches 25*a* and 26*a* by the effect of the intrinsic resiliency of said ring springs 50 and 55, thereby ensuring that the operating body 30 carrying the striker 40 will no longer be separated from the enclosure 20.

It is to be noted that the width of each of the engagement notches 25*a* and 26*a* formed in the guide grooves 25 and 26 is preferably such as to be greater than the diameter of each end pin of the split ring springs 50 and 55 so that a play is not only imparted to the end pins 53*a* and 58*a* within the respective engagement notches 25*a* and 26*a*, but also an accurate engagement of these end pins of the split ring springs into these engagement notches upon return of the striker 40 to the engaged position can be advantageously ensured.

In the foregoing first preferred embodiment of the present invention, the positionings of the pair of the openings 34 and 35 of the operating body 30 and of the guide grooves 25 and 26 of the enclosure 20 have been described as respectively arranged in inverted relation. However, these positionings may be respectively in registered relation substantially as shown in FIG. 4. In addition, the shape of each of the openings 34 and 35 and concurrently the shape of each of the guide grooves 25 and 26 may be such as shown in FIG. 5 wherein the opening 34 is of the substantially isosceles triangular shape and has a pair of slant edges 34*a* and 34*c'* while the guide groove 25 has a pair of engagement notches 25*a* and 25*a'*. Furthermore, a combination of each one of the openings 34 and 35 and the guide grooves 25 and 26 may be omitted as shown in FIG. 5 or may be of the rectangular shape as shown in FIG. 6.

Hereinafter, description which may apply to the second preferred embodiment of the present invention will be made in connection with the design of each of the split ring springs employed. As hereinbefore described, the angle of segment between the end pins 53*a* and 53*b* or 58*a* and 58*b* of each pair is preferably selected to be approximately 45°. This is because, if this angle of segment is more than this approximation, a relatively great force will be required in gripping the end pins in the opposing direction and, hence, a relatively great finger pressure must be applied to the closed end of the operating body 30. On the other hand, if this angle of segment is smaller than said approximation, the striker 40 will have a tendency to be disengaged from the engaged position before a sufficient amount of energy is accumulated by the compression spring 60 and, hence, a sufficient impact cannot be given to the piezoelectric element 10. Furthermore, the length of each of the end pins 53*a*, 53*b*, 58*a* and 58*b* is preferably such that the free end thereof, which is opposed to the other end integrally connected with the circular portion 51 or 56 may not be projected outside the piezoelectric igniter proper. This length of said end pins of the split ring springs can be adjusted at any time before and after the assemblage of the piezoelectric igniter completes, by means of any suitable method.

The shape of each of the split ring springs 50 and 55 which has been described as of the Ω form may be such as indicated by A, B, C, D, E, F, G or H in FIG. 7. In FIG. 7, it is to be noted that the real circular line indicates the cross-section of the striker 40 and the imaginary circular line indicates the depth of the groove 41*a* or 41*b*. Although employment of one or two spring elements, each shaped such as indicated by A through H in FIG. 7, in lieu of the omega-shaped split ring springs ensures a satisfactory function or performance of the igniter of the present invention, the present invention does not pertain to the provision of such spring elements as shown in FIG. 7 and, therefore, detailed description of FIG. 7 is herein omitted.

Attention is now directed to the arrangement of each of the guide grooves 25 and 26 which is substantially channel-shaped over the depth thereof and also to the arrangement of each of the opening 34 and 35 which are half-encircled by the respective restricting members 31*c* and 32*c* extending integrally from the slant edges 34*a* and 35*a*. However, in order to ensure a comparatively smoother return movement of the striker 40 and, thus, the operating body 30, there is provided a second preferred embodiment of the present invention, which will be hereinafter described with reference to FIGS. 8 through 10.

It is to be noted that this second preferred embodiment of the present invention has an additional advantage in that a possible displacement of either or all of the split ring springs 50 and 55 with respect to the plane perpendicular to the longitudinal axis of the striker 40 can be prevented. This displacement may oftentimes occur incident to the employment of the compression spring 60 of a relatively great resiliency since the other of the end pins, such as indicated by 53*b* and 58*b* in the foregoing preferred embodiment, of each pair in the split ring springs 50 and 55 is not adapted to engage into engagement notches of configuration similar to those indicated by 25*a* and 26*a*.

Referring now to FIGS. 8 through 10, each of the guide grooves 25 and 26 formed in the both side plates 21 and 22 of the enclosure 20 is modified so as to represent the substantially tapered shape as indicated by 25' and 26' and provided with an abutment step 25*b* or 26*b* arranged in opposed relation to the engagement notch 25*a* or 26*a* so that the both end pins 53*a* and 53*b* or 58*a* and 58*b* of each split ring spring 50 or 55 can be trapped by the engagement notch 25*a* or 26*a* and the abutment step 25*b* or 26*b*, respectively, upon the return movement of the striker 40.

In addition, each of the openings 34 and 35 formed in the both side plates 31 and 32 of the operating body 30 is modified in such a manner that the restricting member 31*c* or 32*c* shown in the foregoing embodiment as formed integrally with the slant edge 34*a* or 35*a* is, as indicated by 31*c'* or 32*c'* in FIG. 8, formed integrally with the guide edge 34*c* or 35*c*.

In this second preferred embodiment shown in FIGS. 8 through 10, the provision of the tapered guide grooves 25' and 26' clearly facilitates the smoother return movement of the operating body 30 in relation to the enclosure 20 than afforded by the foregoing embodiment. This is because this return movement is effected not only by the return spring 70, but also by the circumferentially outwardly acting resiliency of each of the gripped split ring springs 50 and 55 during said return movement. In other words, during this return movement, the contact pressure exerted between the pairs of the end pins 53*a*, 53*b* and 58*a*, 58*b* and the respective guide grooves 25' and 26' is advantageously reduced in view of the particular shape of each of said guide grooves 25' and 26'.

Furthermore, because of the provision of the restricting members 31*c*' and 32*c*' respectively integral with the guide edges 34*c* and 35*c*, the striker 40 upon completion of its movement to the engaged position can be firmly engaged in said engaged position in such a way that the end pins 53*a* and 58*a* are collapsed into the respective engagement notches 25*a* and 26*a* while the other end pins 53*b* and 58*b* are respectively restricted by the abutment steps 25*b* and 26*b*. Accordingly, the prevention of the possible displacement of each split ring springs 50 and 55 with respect to the plane perpendicular to the longitudinal axis of the striker is advantageously ensured. Of course, no increased finger pressure is required to operate the operating body 30 so as to move the latter in relation to the enclosure 20.

In this second preferred embodiment, it is to be noted that portions indicated by 25*c* and 26*c* in FIG. 8 may be omitted. In this case, the opening of each of the grooves 25' and 26' should be sized so as to be smaller than the spacing of the corresponding gap 52 or 57 of the split ring springs 50 and 55. In any event, the assemblage can be followed in the same manner as practised in the foregoing embodiment without any reduction of the performance and also without any increase of the manufacturing cost.

In either of the foregoing first and second preferred embodiments of the present invention, the enclosure and the operating body may be respectively in the cylindrical shape. In this case, no additional processing work is required such as necessitated in the abovementioned prior art device for preventing the relative displacement between the operating body and the striker.

Although the present invention has been fully described by way of example in conjunction with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. For example, instead of the employment of the split ring spring having the circular portion, a similar split spring element having a substantially elliptical portion may be employed. In this case, the minimum inner diameter of the similar split spring element should be substantially equal to the diameter of the grooved portion of the striker, so that a pair of the end pins can be prevented from being collapsed innerwardly with respect to the piezoelectric igniter proper during the use of the latter.

Accordingly, such changes and modifications should be construed as included within the scope of the present invention, unless otherwise they depart therefrom.

We claim:

1. A piezoelectric igniter comprising:

an enclosure containing therein a piezoelectric element capable of generating a high-voltage spark across a spark gap upon receipt of a sufficient impact given thereto;

an operating body telescoped with said enclosure, said operating body being normally maintained at a first axial position with respect to said enclosure and being capable of axial movement toward said enclosure upon receipt of an external force applied thereto from the outside;

a striker axially mounted between said enclosure and operating body and slidable in the direction of the axis of said enclosure, said striker being provided with at least one split spring element, having a pair of radially outwardly extending end pins, said pair of end pins being engaged by individual portions of at least either one of said enclosure or said operating body when said operating body is at said first axial position;

at least one spring axially mounted between said striker and operating body for applying to said striker an axial pushing force and for accumulating sufficient energy by compression during at least part of said axial movement of said operating body toward said enclosure to insure generation of the high-voltage spark when said sufficient impact is given to said piezoelectric element; and

means having at least one slant edge and a guide edge in cooperative relation to said slant edge, said slant edge and guide edge being formed on that one of said enclosure or said operating body to which said end pins are not engaged, and being capable of gripping said end pins inwardly with respect to each other during said movement of said operating body toward said enclosure, thereby to disengage said pins from said individual portions and to release the accumulated energy of said spring in accordance with the movement of said operating body so that said striker is permitted to strike against said piezoelectric element to apply the impact thereto.

2. A piezoelectric igniter as claimed in claim 1, wherein an additional spring is provided for effecting a return movement of said operating body to the first axial position after said operating body has been moved toward said piezoelectric element to give the sufficient impact to said piezoelectric element.

3. A piezoelectric igniter as claimed in claim 1, wherein said striker is of cylindrical shape and formed on its periphery with at least one groove for accommodating therein said split spring element provided thereto.

4. A piezoelectric igniter as claimed in claim 1, wherein said enclosure and said operating body are respectively in the shape of a box and are fitted to each other in such a manner that either of them constitutes a guide for the other.

5. A piezoelectric igniter comprising an enclosure containing therein a piezoelectric element capable of generating a high voltage spark across a spark gap upon receipt of a sufficient impact given thereto; an operat-

ing body fitted to said enclosure with a first spring interposed therebetween and movable in the axial direction of said enclosure upon receipt of an external force applied thereto from the outside; a striker of cylindrical shape being slidable in the direction of the axis of said enclosure and provided on its periphery with at least one groove; at least one second spring for applying to said striker an axial pushing force and for accumulating sufficient energy necessary to insure generation of the high voltage spark when said sufficient impact proportional to the amount of energy accumulated is given to said piezoelectric element; at least one split spring element having a substantially circular portion and a pair of radially outwardly extending end pins integral with said circular portion and elastically engaged in said groove of said striker, said circular portion encircling the depth of said groove, said pair of said end pins being projected through an opening formed on at least one side of each of said enclosure and said operating body, one of said openings being formed with a guide groove and an engagement notch and the other of said openings having a slant edge and a guide edge by which said end pins are inwardly gripped with respect to each other to disengage one of said end pins, that has been engaged into said engagement notch, thereby to release the accumulated energy of said second spring in accordance with the movement of said operating body so that said striker is permitted to striker against said piezoelectric element to apply the impact thereto.

6. A piezoelectric igniter as claimed in claim 5, wherein said guide edge is provided integrally with a restricting member and said guide groove is provided with an abutment step whereby the other of said end pins which is not engaged into the engagement notch can be firmly secured by said abutment step for avoiding a possible displacement of said split spring element with respect to the plane perpendicular to the axis of said striker.

7. A piezoelectric igniter as claimed in claim 5, wherein said guide groove is of the shape substantially tapered toward its depth whereby a smooth return movement of said operating body can be facilitated by said first spring interposed between said operating body and said enclosure.

8. In a piezoelectric igniter of the type including:

1. an enclosure containing therein a piezoelectric element capable of generating a high-voltage spark across a spark gap upon receipt of a sufficient impact against the end thereof;
2. an operating body telescoped with said enclosure and axially movable into said enclosure by an external force applied thereto;
3. an axially displaceable striker body mounted between said piezoelectric element and said operating member with an energy accumulating spring between said striker and operating body and a return spring between said striker and piezoelectric element;
4. means for axially restraining said striker body against movement toward said piezoelectric element upon initial movement of said operating body into said enclosure whereby to permit accumulation of energy in said energy accumulating spring; and
5. means to release said striker body for impact upon said piezoelectric element upon displacement of said operating member toward said piezoelectric element a predetermined distance, whereby to permit the energy accumulated in said energy accumulating spring to be dissipated by said impact; the improvement wherein:

said means for restraining said striker body comprises a pair of split spring elements mounted in grooves extending about said striker body in a direction transverse to the axis thereof, each of said elements having a pair of radially outwardly extending end pins, each said pair of pins extending in opposite directions, and the walls of said enclosure being provided with a pair of axially extending slots for receiving each of said pair of pins, at least one shoulder being present at each slot for engaging a pin member of each said pair to effect said restraint of said striker body; and wherein

said release means comprises a pair of slots formed in the walls of said operating body adjacent to said slots of said enclosure, each of said operating body slots being provided with an inclined surface which progressively bears against at least one pin member of said pin pair upon movement of said operating body into said enclosure, thereby by cam action pinching said member pins toward one another, thereby displacing said engaged pin member from said shoulder to effect said release of said striker body.

* * * * *