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(54) PIEZOELECTRIC HIGH VOLTAGE GENERATING DEVICE

(71) We, MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD., a corporation organised under the laws of Japan, of 1006, Oaza Kadoma, Kadoma-shi, Osaka, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:–

The present invention relates to a high voltage generating device for generating a high voltage by applying an impact force to a piezoelectric element.

According to the present invention there is provided a high voltage generating device comprising an outer housing of insulating material in which a piezoelectric element is housed, an abutment and terminal member each contacted to respective end surfaces of said piezoelectric element, an inner housing supporting a hammer for imparting an impact force to said abutment, said hammer being movably mounted within said inner housing, said inner housing being slidably supported in a space within said outer housing, a hole with a sloped cam portion formed in a side surface of said inner housing spring means mounted within said inner housing for biassing said hammer outwardly of said inner housing, a spring for loading said inner housing outwardly of said outer housing, an L-shaped latch groove formed in an inner wall of said outer housing, and a pin mounted on said hammer, a tip end of said pin projecting through said hole in said inner housing and engaging said L-shaped latch groove of said outer housing, whereby in use said cam portion of said hole engages said pin as said inner housing is slid inwardly with respect ot said outer housing so that said pin moves in said groove to a point at which it is released thereby to permit said spring means to strike said hammer against said abutment.

The invention will now be described by way of example only with particular reference to the accompanying drawings wherein:

Figs. 1 and 2A, 2B illustrate an embodiment of the present invention, in sectional view and in perspective view, respectively;

Fig. 3 shows a part of the embodiment;

Fig. 4 illustrates another embodiment and

Figs. 5 to 9 show further embodiments.

Referring now to Figs. 1 and 2 (A, B), an outer housing 1 made of an insulating material such as resin has a bore formed therein, in which bore an abutment 2, a piezoelectric element 3, a center terminal board 4 and a piezoelectric element 5 are mounted in this order and blocked by a terminal end member 6 of electrically conductive material. L-shaped grooves 7, 7′ are formed in inner side walls of the outer housing 1 with the grooves 7, 7′ being open at the open end of the outer housing 1. A frame 9 is fitted into the outer housing 1. The frame 9 is formed with a projection 10 which is adapted to engage a hole 11 formed in the outer housing 1 to lock the frame 9 to the outer housing 1. The open areas of the grooves 7, 7′ formed on the inner walls of the outer housing 1 are closed by the sides of the frame 9 to form L-shaped grooves. An inner housing 12 is formed with a hole 13 having a cam surface 13′, and it is made of an insulating material such as resin, or a conductive material. Housed in the inner housing 12 are a hammer 14 and a spring 15 for imparting an advance force to the hammer 14. A pin 16 is mounted on the hammer 14 to extend beyond hole 13. The inner housing 12 extends through the frame 9 and it is slidably supported by the outer housing 1 with the pin 16 being fitted in the grooves 7, 7′. A spring 17 is mounted in a space 8 within the outer housing 1. The opposite ends 17, 17″ of the spring 17 are shaped to align with the axes of the spring 17 (see Fig. 3), and one end 17′ of the spring 17 is

inserted into a hole 18 formed in the outer housing 1 and the tip end thereof makes contact with the terminal member 6. The other end 17" of the spring 17 continuously contacts with the side of the hammer 14. While the inner housing 12 is biased outwardly by the spring 17, the outward movement thereof is limited because the pin 16 abuts against the end surfaces of the frame 9.

Fig. 1 is a side sectional view showing one side of the assemblage comprising the inner housing and outer housing; the two L-shaped grooves are formed on the inside opposite walls of the outer housing 1 respectively in such a relation that they are angularly rotated by 180 degrees tm each other (as shown in Figs. 2A and 2B); these are accordingly provided in practice two projections of the pin 16 and two holes 13 in place respectively on the hammer 14 and on the inner housing so that the two projections of the pin 16 engage and cooperate with the respective L-shaped grooves through the respective holes.

In Fig. 1, when the inner housing 12 is urged toward the outer housing 1 against the force of the spring 17, the spring 17 is compressed together with compression of the spring 15. During this movement, the hammer is maintained stationery because the pin is retained in the stepped portion of the grooves 7, 7'. As the inner housing 12 is further urged, the pin 16 slides on the cam surface 13' so that the pin 16 is disengaged from the upstanding step portion of the grooves 7, 7'. As a result, the hammer 14 abruptly moves leftward by the force of the spring 15 to strike the abutment 2 for causing the piezoelectric elements 3, 5 to generate a high voltage. When the abutment 2 is struck by the hammer 14, the abutment 2 is connected to the terminal member 6 through the hammer 14 and the spring 17.

In the present embodiment, the outer housing 1 is made of insulating material such as resin and the sides of the outer housing 1 are not formed with L-shaped holes but the inner side walls of the outer housing 1 are formed with L-shaped grooves 7 and 7'. Accordingly, a noise generated when the hammer 14 strikes the abutment 2 does not leak outside the outer housing 1 and hence the impact noise can be reduced. Furthermore, in the present embodiment, since the frame 9 is fitted into and affixed to the outer housing 1 so that the end surfaces of the frame 9 from the side walls of the L-shaped grooves 7, 7', the manufacture of the outer housing 1 is facilitated.

Fig. 4 shows another embodiment of the present invention. While the previous embodiment engages the projection 10 with the hole 11 to lock the frame 9 to the outer housing 1, the embodiment of Fig. 4 bends the end of the outer housing 1 inward to lock the frame 9 to the outer housing 1.

Fig. 5 shows another embodiment of the present invention, in which the same parts as in Fig. 1 bear the same reference numerals. In Fig. 5, a projection 20 is formed at the end of the outer housing 1, the outer peripheral surface of the projection 20 being threaded. A terminal member 21 has a depression formed at one end surface thereof, the inner peripheral surface of the depression being threaded. By thread coupling the terminal member 21 to the projection 20 of the outer housing 1, the terminal member 21 is fixed to the end of the outer housing 1. Under this mounting condition, the end surface of the piezoelectric element 5 contacts with the terminal member 21. A conductive coating 22 is applied on the outer peripheral surfaces of the terminal member 21 and the outer housing 1.

Fig. 7 shows a further embodiment of the present invention, in which a conductive plate 23 has its one end sandwiched by the terminal member 21 and the outer housing 1.

The embodiments of Figs. 5 and 7 provide an advantage that the present high voltage generating device can be readily grounded by merely housing the same in a metal case such as a cigarette lighter while makiny the terminal member 21 contact with the metal case. Furthermore, in Fig. 5, the conductive coating 22 is applied on the outer peripheral surfaces of the terminal member 21 and the outer housing 1 made of the insulating material such as resin, and in Fig. 7, the conductive plate 23 is provided. Accordingly, the device can be positively grounded by making the conductive coating 22 or the conductive plate 23 contact the metal case.

Fig. 6 shows another embodiment of the present invention. The difference from the embodiment of Fig. 1 is the inclusion of a member 23' of an elastic material such as rubber in a space behind the terminal member 6. According to the present embodiment, when the abutment 2 is struck by the hammer, the impact transmitted through the abutment 2, the piezoelectric element 3, the center terminal board 4, the piezoelectric element 5 and the terminal member 6 is absorbed by the elastic member 23' to further reduce the impact noise.

As is apparent from the above embodiments, according to the present invention, the outer housing for housing the piezoelectric elements is formed by the insulating material such as resin and the grooves are formed in the inner wall of the outer housing. Accordingly, the impact noise generated when the abutment is struck by the hammer does not leak outside the housing and hence the impact noise can be reduced. Furthermore, in the present invention, one

end of the piezoelectric element 3 and the receptacle member are electrically connected together through the spring which biases the inner housing outwardly of the outer housing, and through the hammer. In this manner, the connection of the one end of the piezoelectric element 3 with the receptacle member, which has been a problem encountered in the outer housing made of the insulating material, is attained without necessitating additional parts.

Figs. 8 and 9 show an inner housing in a further embodiment, in which the inner housing 12 is shaped to present a substantially square tube, in section, with two diagonally opposing corners being rounded or arcuate. A pin 16 projects beyond a hole 13 formed in the side of the inner housing 12 so that tip ends of the pin 16 are located on the arcuate corners 24, 24'. According to the present embodiment, the diameter of the square tubular outer housing 1 for slidably supporting the inner housing 12 can be reduced compared with the case where a square tubular inner housing is used, and hence the size of the entire structure can be reduced.

WHAT WE CLAIM IS:-

1. A high voltage generating device comprising an outer housing of insulating material in which a piezoelectric element is housed, an abutment and a terminal member each contacted to respective end surfaces of said piezoelectric element, an inner housing supporting a hammer for imparting an impact force to said abutment, said hammer being movably mounted within said inner housing, said inner housing being slidably supported in a space within said housing, a hole with a sloped cam portion formed in a side surface of said inner housing, spring means mounted within said inner housing for biassing said hammer outwardly of said inner housing, a spring for loading said inner housing outwardly of said outer housing, an L-shaped latch groove formed in an inner wall of said outer housing, and a pin mounted on said hammer, a tip end of said pin projecting through said hole in said inner housing and engaging said L-shaped latch groove of said outer housing, whereby in use said cam portion of said hole engages said pin as said inner housing is slid inwardly with respect to said outer housing so that said pin moves in said groove to a point at which it is released thereby to permit said spring means to strike said hammer against said abutment.

2. A high voltage generating device as claimed in claim 1 wherein the L-shaped groove is open to an open end of said outer housing and a frame defining an opening through which said inner housing extends is fixed in the open end of said outer housing to close the L-shaped groove.

3. A high voltage generating device as claimed in Claim 2 wherein a projection is formed on an outer peripheral surface of the frame, a hole is formed near the opening of said outer housing, and said frame is fitted in said outer housing such that said projection engages said hole to lock said frame to said outer housing.

4. A high voltage generating device as claimed in Claim 2 wherein said frame is inserted into the open end of said outer housing, and the open end of said outer housing is bent inward to lock the frame to said outer housing.

5. A high voltage generating device as claimed in Claim 1 wherein opposite ends of said spring are aligned with the axis of the spring, and one of the ends of said spring is made to contact with a side of said hammer while the other end is made to contact with said terminal member through a hole formed in said outer housing.

6. A high voltage generating device as claimed in Claim 1 wherein a projection is formed at one end of said outer housing adjacent said piezoelectric element, said projection being threaded on an outer peripheral surface thereof, said terminal member including a depression, an inner peripheral surface of which is threaded, and said terminal member is thread coupled to said projection to allow said terminal member to contact said piezoelectric element.

7. A high voltage generating device as claimed in Claim 6 wherein a conductive coating is applied on said terminal member and the outer peripheral surface of said outer housing.

8. A high voltage generating device as claimed in Claim 1 wherein a hole is formed at one end of said outer housing adjacent said piezoelectric element, the inner peripheral surface of said hole being threaded, and said terminal member includes a threaded portion on the outer periphery thereof, whereby said terminal member is coupled in said hole to allow said terminal member to contact with the end surface of said piezoelectric element.

9. A high voltage generating device as claimed in Claim 8 wherein an elastic member is housed in a space in said hole within said outer housing behind said terminal member.

10. A high voltage generating device as claimed in Claim 6 wherein a grounding conductive plate is provided, one end of said conductive plate being sandwiched between said terminal member and said outer housing.

11. A high voltage generating device as claimed in Claim 1 wherein said inner housing supporting said hammer is shaped to present a substantially square tube in section

end of the piezoelectric element 3 and the receptacle member are electrically connected together through the spring which biases the inner housing outwardly of the outer housing, and through the hammer. In this manner, the connection of the one end of the piezoelectric element 3 with the receptacle member, which has been a problem encountered in the outer housing made of the insulating material, is attained without necessitating additional parts.

Figs. 8 and 9 show an inner housing in a further embodiment, in which the inner housing 12 is shaped to present a substantially square tube, in section, with two diagonally opposing corners being rounded or arcuate. A pin 16 projects beyond a hole 13 formed in the side of the inner housing 12 so that tip ends of the pin 16 are located on the arcuate corners 24, 24'. According to the present embodiment, the diameter of the square tubular outer housing 1 for slidably supporting the inner housing 12 can be reduced compared with the case where a square tubular inner housing is used, and hence the size of the entire structure can be reduced.

WHAT WE CLAIM IS:–

1. A high voltage generating device comprising an outer housing of insulating material in which a piezoelectric element is housed, an abutment and a terminal member each contacted to respective end surfaces of said piezoelectric element, an inner housing supporting a hammer for imparting an impact force to said abutment, said hammer being movably mounted within said inner housing, said inner housing being slidably supported in a space within said housing, a hole with a sloped cam portion formed in a side surface of said inner housing, spring means mounted within said inner housing for biassing said hammer outwardly of said inner housing, a spring for loading said inner housing outwardly of said outer housing, an L-shaped latch groove formed in an inner wall of said outer housing, and a pin mounted on said hammer, a tip end of said pin projecting through said hole in said inner housing and engaging said L-shaped latch groove of said outer housing, whereby in use said cam portion of said hole engages said pin as said inner housing is slid inwardly with respect to said outer housing so that said pin moves in said groove to a point at which it is released thereby to permit said spring means to strike said hammer against said abutment.

2. A high voltage generating device as claimed in claim 1 wherein the L-shaped groove is open to an open end of said outer housing and a frame defining an opening through which said inner housing extends is fixed in the open end of said outer housing to close the L-shaped groove.

3. A high voltage generating device as claimed in Claim 2 wherein a projection is formed on an outer peripheral surface of the frame, a hole is formed near the opening of said outer housing, and said frame is fitted in said outer housing such that said projection engages said hole to lock said frame to said outer housing.

4. A high voltage generating device as claimed in Claim 2 wherein said frame is inserted into the open end of said outer housing, and the open end of said outer housing is bent inward to lock the frame to said outer housing.

5. A high voltage generating device as claimed in Claim 1 wherein opposite ends of said spring are aligned with the axis of the spring, and one of the ends of said spring is made to contact with a side of said hammer while the other end is made to contact with said terminal member through a hole formed in said outer housing.

6. A high voltage generating device as claimed in Claim 1 wherein a projection is formed at one end of said outer housing adjacent said piezoelectric element, said projection being threaded on an outer peripheral surface thereof, said terminal member including a depression, an inner peripheral surface of which is threaded, and said terminal member is thread coupled to said projection to allow said terminal member to contact said piezoelectric element.

7. A high voltage generating device as claimed in Claim 6 wherein a conductive coating is applied on said terminal member and the outer peripheral surface of said outer housing.

8. A high voltage generating device as claimed in Claim 1 wherein a hole is formed at one end of said outer housing adjacent said piezoelectric element, the inner peripheral surface of said hole being threaded, and said terminal member includes a threaded portion on the outer periphery thereof, whereby said terminal member is coupled in said hole to allow said terminal member to contact with the end surface of said piezoelectric element.

9. A high voltage generating device as claimed in Claim 8 wherein an elastic member is housed in a space in said hole within said outer housing behind said terminal member.

10. A high voltage generating device as claimed in Claim 6 wherein a grounding conductive plate is provided, one end of said conductive plate being sandwiched between said terminal member and said outer housing.

11. A high voltage generating device as claimed in Claim 1 wherein said inner housing supporting said hammer is shaped to present a substantially square tube in section

with two diagonally opposing arcuate corners, and said pin mounted on said hammer extending through the hole of said inner housing to be positioned at said arcuate corners.

12. A high voltage generating device substantially as hereinbefore described and as shown in Figures 1 to 3 or Figure 4, or 5, or 6, or 7 or 8 and 9 of the accompanying drawings.

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