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[54] **HIGH VOLTAGE GENERATING PIEZOELECTRIC IGNITER**

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[52] **U.S. Cl.** **310/8.7**, 317/DIG. 11
[51] **Int. Cl.** **H04r 17/00**, H03k 3/00
[58] **Field of Search** ..... 310/8.3, 8.7, 9.1; 317/79 PZ, DIG. 11; 315/55, 209 PZ; 431/255

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[57] **ABSTRACT**

A static pressure type high voltage generating device of the kind in which a high voltage is generated by applying a static pressure to piezoelectric elements and which has simple structure, requires only a small operating force and moreover is excellent in durability.

6 Claims, 8 Drawing Figures

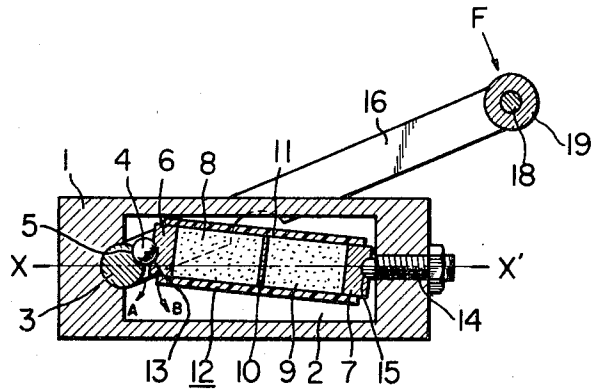


FIG. 1

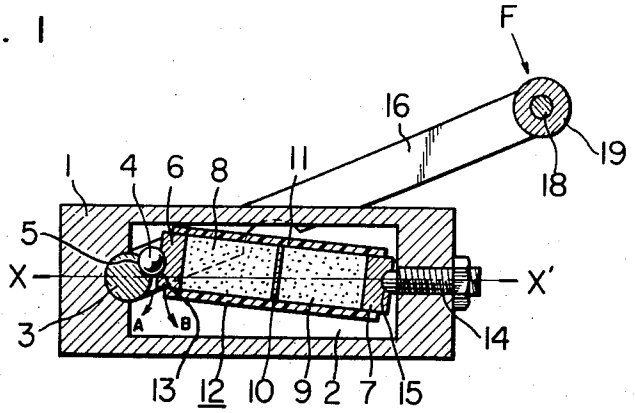


FIG. 2

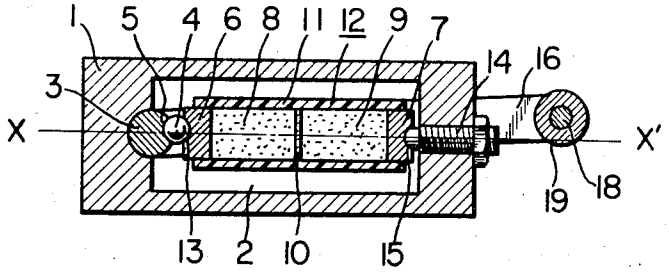


FIG. 3

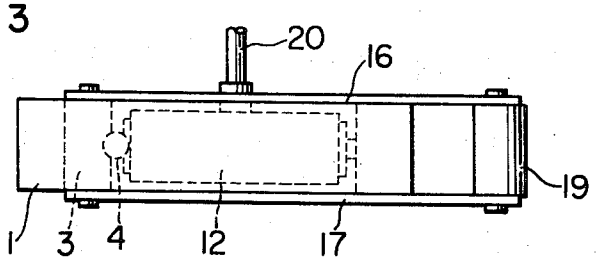


FIG. 4

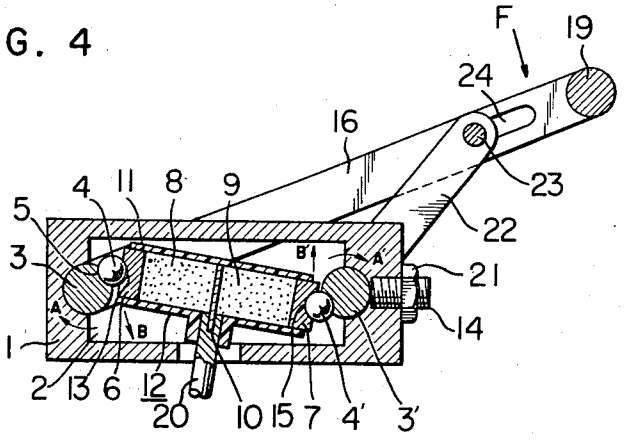


FIG. 5

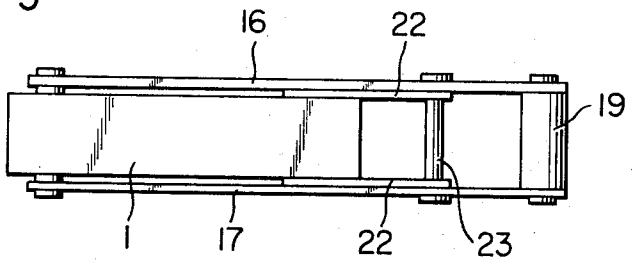


FIG. 6

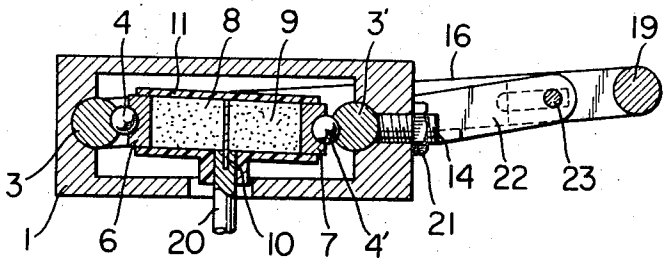


FIG. 7

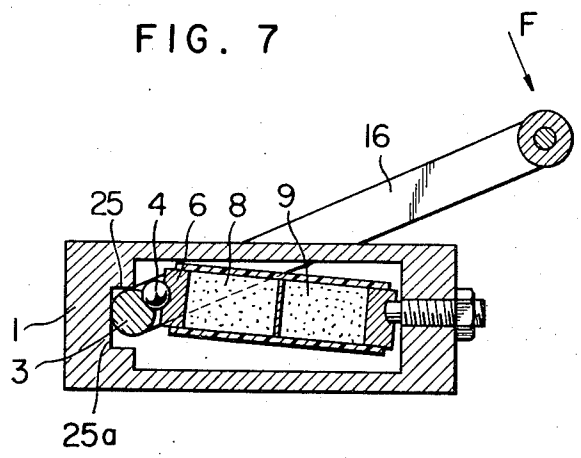
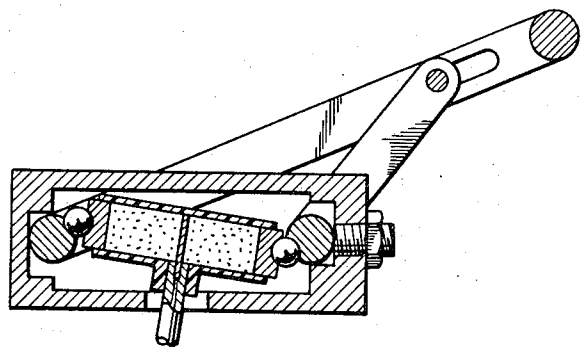


FIG. 8



HIGH VOLTAGE GENERATING PIEZOELECTRIC IGNITER

The present invention relates to a high voltage generating device in which a high voltage is generated by applying a static pressure to piezoelectric elements.

Generally, there are two methods in which a piezoelectric element is employed to generate high voltage. One is an impact type in which an impulsive force is applied instantaneously to a piezoelectric element and the other is a static pressure type in which a static pressure is applied to a piezoelectric element.

Of such high voltage generating devices, the impact type produces high voltage only once and therefore if an ignition system is constructed by employing a high voltage generating device of this type, the resultant ignition system will be suited for use with LP gas or town gas which is highly ignitable, but it will not be used with natural gas which is not easily ignitable.

On the other hand, the static pressure type produces high voltage continuously and therefore, if it is incorporated in an ignition system, the resultant ignition system has an advantage in that due to the occurrence of sparks by several discharges, the ignition can be effected positively.

However, this static pressure type has a drawback in that as compared with the impact type, the structure is complicated thus making its assembly more difficult and disadvantageous from the aspect of manufacturing cost.

For example, in the case of conventional high voltage generating devices of the type in which high voltage is produced by applying a static pressure to a piezoelectric element, most of these devices relied on a method of applying a simple linear pressure to a piezoelectric element or a method in which one end of a piezoelectric element is utilized as a fulcrum to impart a pendulum motion to the other end of the piezoelectric element.

While various kinds of static pressure type high voltage generating devices have been developed as mentioned above, none of such devices have been satisfactory from the stand-point of manufacturing cost, performance and durability.

It is therefore a general object of the present invention to eliminate the drawbacks of the prior art devices.

It is an object of the present invention to provide a high voltage generating device which has simple structure, requires small operating force and is superior in durability.

It is another object of the present invention to provide a high voltage generating device of simple structure in which a pressure is applied to the center of a piezoelectric element unit to effectively develop a strain in the piezoelectric elements, reducing the required operating force and thus ensuring a very good feeling of touch.

In accordance with the present invention, a high voltage generating device is provided which comprises a pivot mounted on one inner end of a metal frame and secured to operating levers, a ball mounted in a recess formed on the outer surface of the pivot, and a piezoelectric element unit held between a screw attached to the other end of the metal frame and the ball, whereby the piezoelectric element unit is deviated from the center line of the metal frame joining the pivot and the screw.

Other objects, features and advantages of the present invention will be readily apparent from the detailed descriptions hereinbelow taken in conjunction with the accompanying drawings, in which:

FIGS. **1** and **2** are sectional views showing an embodiment of a high voltage generating device according to the present invention;

FIG. **3** is a plan view of the high voltage generating device shown in FIGS. **1** and **2**;

FIG. **4** is a sectional view of a second embodiment of the high voltage generating device according to the present invention;

FIG. **5** is a plan view of FIG. **4**;

FIG. **6** is a sectional view showing the conditions in the device of the second embodiment in operation;

FIG. **7** shows a third embodiment having a further improvement according to the invention; and

FIG. **8** shows a similar modification of the structure of FIG. **3.**

In the drawings, like reference numerals refer to like parts.

The present invention will now be explained with reference to FIGS. **1** to **3** illustrating a first embodiment of the invention. In the figures, numeral **1** designates a metal frame having formed therein a chamber **2** which is opened on both sides, and a pivot or cylindrical operating roller **3** is rotatably mounted on one inner end of the metal frame **1.** The pivot **3** is formed in a part of the outer surface thereof with a recess **5** into which is fit a pressure member **4,** e.g., a cylindrical steel or steel ball. Disposed in the chamber **2** of the metal frame **1** is a piezoelectric element unit **12** comprising metal pads **6** and **7** provided on both ends of the unit, piezolelectric elements **8** and **9** disposed between the metal pads **6** and **7,** a center terminal **10** disposed between the piezoelectric elements **8** and **9,** and a housing **11** of a plastic resin, for example, in which the aforesaid members are encapsulated.

The metal pad **6** of the piezoelectric element unit **12** is formed with a recess **13** for receiving the steel ball **4,** and the other metal pad **7** is formed with a recess for receiving the tip of a screw **14** threadedly secured to the other end of the metal frame **1.**

One ends of operating levers **16** and **17** are secured to the ends of the pivot **3** and a lever roller **19** is mounted between the other ends of the operating levers **16** and **17** by means of a pin **18.**

A high voltage lead wire **20** is taken out from the center terminal **10** of the piezoelectric element unit **12.**

With this arrangement, the piezoelectric element unit **12** is supported between the steel ball **4** and the screw **14** making a small angle with the center line of the metal frame **1,** i.e., a line X—X′ interconnecting the centers of the pivot **3** and the screw **14.**

The operation of this embodiment is as follows. When a force in the F direction in FIG. **1** is applied to the lever roller **19,** the operating levers **16** and **17** are rotated clockwise about the pivot **3** and this rotational movement of the operating levers **16** and **17** is transmitted to the pivot **3** with the result that the rotation of the pivot **3** in the A direction causes the steel ball **4** to be moved through the same angle of rotation. This movement of the steel ball **4** causes the piezoelectric element unit **12** also to be moved in the direction of B arrow with the tip of the screw **14** acting as its support-

ing point. That is, the piezoelectric element unit **12** is changed from the position shown in FIG. **1** to the position shown in FIG. **2.**

As a result of this movement, the piezoelectric elements **8** and **9** are compressed by an amount corresponding to the displacement thereof so that a high voltage can be continuously delivered from the high voltage lead wire **20.**

When the force in the F direction which has been applied to the lever roller **19** is released, the piezoelectric element unit **12** is returned to its initial position due to the resiliency of the piezoelectric elements **8** and **9,** that is, the unit returns from the position of FIG. **2** to the position shown in FIG. **1.** In this case, since the piezoelectric elements **8** and **9** are brought back to the former condition from the previously compressed condition, the same high voltage as generated during the actuation period is also generated continuously during the restoration period.

It will thus be seen that since the first embodiment of the high voltage generating device according to the present invention employs the steel ball combined with the pivot secured to the operating levers to effect the rotational displacement of the piezoelectric element unit, with a simplified structure, a static pressure can be applied to the piezoelectric element unit with a reduced loss of power and moreover a small operating force can result in the application of a large force to the piezoelectric element unit, thereby easily generating a high voltage.

Further, since the steel ball is employed as a means for transmitting the rotational displacement, very smooth movements of the component parts can be ensured.

Accordingly, the required operating force can be reduced and moreover the occurrence of fault can be reduced considerably thus making the device highly efficient in operation.

Furthermore, the simple structure of the device ensures a reduction in the manufacturing cost.

While, in the embodiment so far described, the steel ball has been employed, any other balls of conductive materials which are hard and not easily broken and highly rigid, may also be employed.

Another embodiment of the present invention will now be explained hereunder.

Referring to FIGS. **4, 5** and **6,** there is illustrated a second embodiment of the device of the invention having, in part, the similar structure with the previously explained first embodiment and in the figures the like reference numerals designates the corresponding parts. In the figures, numeral **1** designates the metal frame and the cylindrical pivot **3** is rotatably mounted on one longitudinal end of the frame **1** which acts as a bearing for the pivot **3.** The pivot **3** is formed with the recess **5** on the outer surface thereof for receiving a part of the pressure member **4,** e.g., a cylindrical member or a steel ball, and the metal pad attached onto the end face of the piezoelectric element **8** is likewise formed with a recess for receiving another part of the steel ball **4.**

In other words, the piezoelectric element unit comprising the pivot **3,** the piezoelectric element **8** and so on is assembled with the steel ball **4** being interposed therebetween. On the other hand, a cylindrical rotatable pivot **3'** and the metal pad **7** attached to the end face of the other piezoelectric element **9** are assembled, with a steel ball **4'** interposed therebetween on the other longitudinal end of the frame **1.** Numeral **11** designates the housing containing the piezoelectric elements **8** and **9, 10** the center terminal, **20** the high voltage lead wire. One side of the pivot **3'** is abutted against the tip of the clamp screw **14** to adjust the amount of pressure to be applied to the piezoelectric element unit **12.** Numeral **21** designates a lock nut for fastening the clamp screw **14** to the frame **1.**

With the assembled structure described above, the piezoelectric element unit **12** is held between the steel balls **4** and **4'** making a small angle with the center line of the metal frame **1,** i.e., a line joining the centers of the pivots **3** and **3'.**

Numerals **16, 17** and **22** designate operating levers whose one ends are respectively secured to the ends of the pivots **3** and **3'** to be joined together, and the operating levers **22** are connected to the operating levers **16** and **17** by a connecting pin **23.** Numeral **24** designates slots formed in the operating levers **16** and **17,** in which the connecting pin **23** is moved slidingly. Numeral **19** designates the lever roller for ensuring a smooth actuation provided at the other ends of the operating levers **16** and **17.**

The operation of the second embodiment described above is as follows. When a force in the direction of F arrow is applied to the operating levers **16** and **17,** the operating levers **22** are simultaneously rotated in the direction of the F arrow by virtue of the connecting pin **23** and the slots **24.**

This rotational movement of the operating levers **16, 17** and **22** in the direction of the F arrow causes the pivots **3** and **3'** to rotate in the directions of A arrows so that the piezoelectric element unit is moved and compressed in the directions of arrows B and B', thereby continuously generating a high voltage. The resultant conditions in the device are shown in FIG. **6.** When the force in the direction of the F arrow is removed, all the component parts are brought back to their initial positions by the restoring force of the piezoelectric element unit and the high voltage is also generated continuously during this restoration period.

It is apparent that the high voltage generating device according to the present invention may be constructed as above described and since the ends of the piezoelectric element unit are adapted to be moved slidingly, as compared with the cases where one end of a piezoelectric element unit is fixed, a large strain can be developed in the piezoelectric elements with a smaller stroke and thus high voltage can be easily generated. Accordingly, in contrast to conventional devices, the stroke required for generating the same voltage can be reduced to about one half with resultant greater efficiency in operation. Furthermore, the sliding movements of the ends of the piezoelectric element unit result in a device which ensures an excellent sense of touch on the part of an operator and therefore its practical value is very great.

FIG. **7** illustrates a further improvement in which the dimension of a recess **25** (for receiving the pivot **3**) formed in the inner end of the metal frame **1** is made larger than that of the pivot **3,** for example as shown in FIGS. **7** or **8,** so that when the operating levers **16** and **17** are actuated, the pivot **3** is rolled in the recess **25** thereby applying a pressure to the piezoelectric element unit. In other words, when a force in the F direction is applied to the operating levers **16** and **17,** the

pivot 3 rotates rolling along a surface 25*a* of the recess 25. The same arrangement can also be incorporated in the embodiment of FIGS. 3 to 6 employing two steel balls, which is schematically shown in FIG. 8. The effect of this arrangement is that while, in the embodiments shown respectively in FIGS. 1 to 3 and FIGS. 4 to 6, the mating recess and pivot are in bearing relation and therefore involve sliding friction, in this arrangement of FIGS. 7 or 8 the rolling contact is produced between the mating recess and pivot and thus the required operating force can be reduced and the operation of the device is further smoothed.

What we claim is:

1. A high voltage generating device comprising a metal frame, a pivot mounted on one inner end of said metal frame and secured to a pair of operating levers, said pivot having a recess formed on an outer surface thereof, a ball mounted in said recess, a screw attached to the other end of said metal frame, and a piezoelectric element unit held between said screw and said ball, whereby said piezoelectric element unit is deviated with respect to the center line of said metal frame joining said pivot and said screw.

2. A high voltage generating device according to claim 1, wherein the tip of said screw attached to the other end of said metal frame is fit into a recess formed in one of a pair of metal pads constituting part of said piezoelectric element unit.

3. A high voltage generating device according to claim 1, wherein a second ball is disposed between said screw attached to the other end of metal frame and said piezoelectric element unit, a portion of said second ball being fit in a recess formed in one of a pair of metal pads constituting part of said piezoelectric element unit.

4. A high voltage generating device according to claim 1, wherein a second pivot is disposed between said screw attached to the other end of said metal frame and said piezoelectric element unit, said second pivot having a recess formed in a portion thereof to receive a second ball fit in a recess formed in one of a pair of metal pads constituting part of said piezoelectric element unit, and a second pair of operating levers secured to said second pivot are joined together with said first pair of operating levers.

5. A high voltage generating device according to claim 1, wherein a recess is formed in one inner end of said metal frame, and said pivot is rollably mounted in said recess formed in one inner end of said metal frame.

6. A high voltage generating device according to claim 5, wherein a second pivot is disposed between said screw attached to the other end of said metal frame and said piezoelectric element unit, said second pivot having a recess formed in a portion thereof to receive a second ball fit in a recess formed in one of a pair of metal pads constituting part of said piezoelectric element unit, and a second pair of operating levers secured to said second pivot are joined together with said first pair of operating levers.

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