Nov. 17, 1970 YASUHISA EBINE ET AL 3,540,823

PIEZOELECTRIC SPARK GENERATOR

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Fig. 1

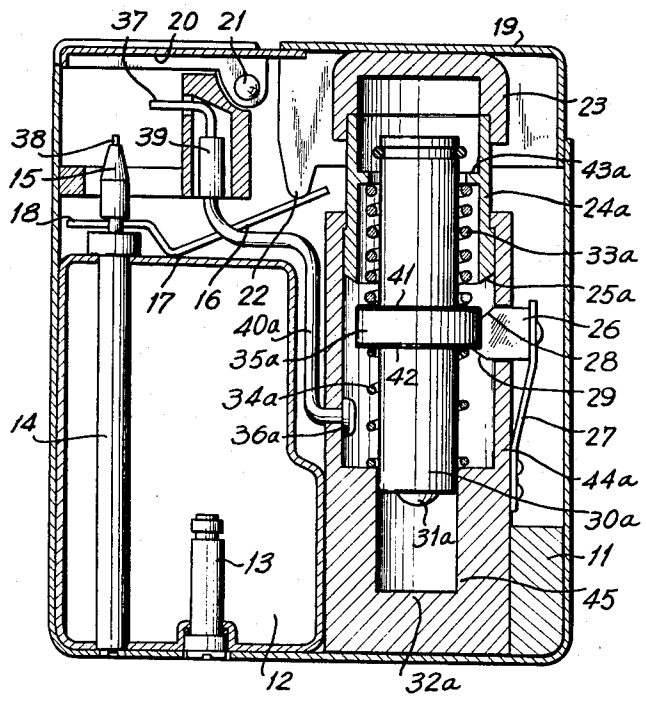


Fig. C

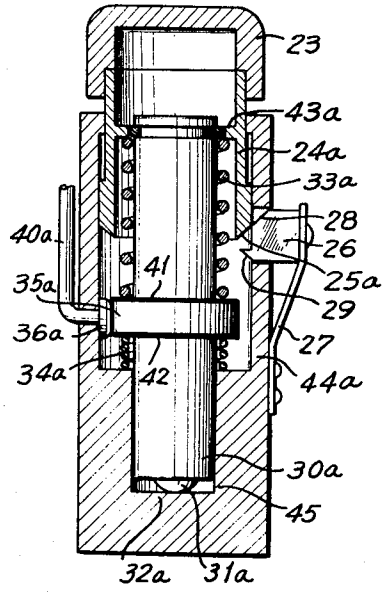


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Fig. 3

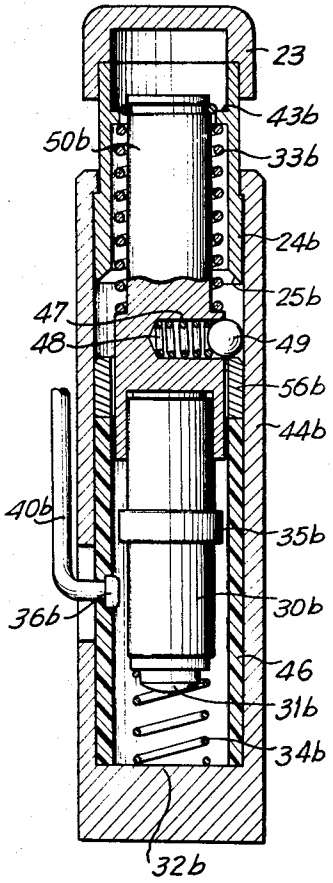


Fig. 4

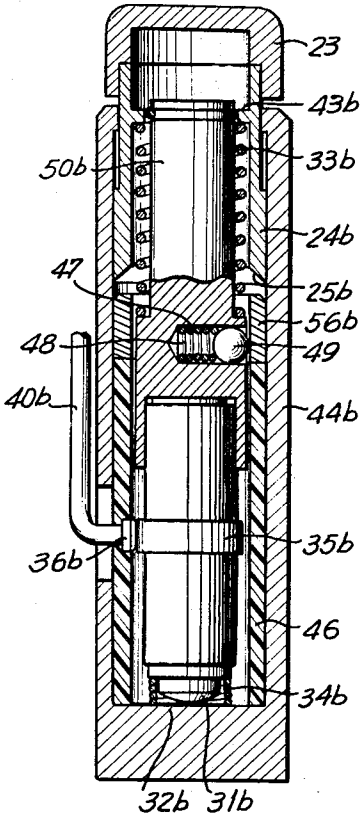


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Fig. 5

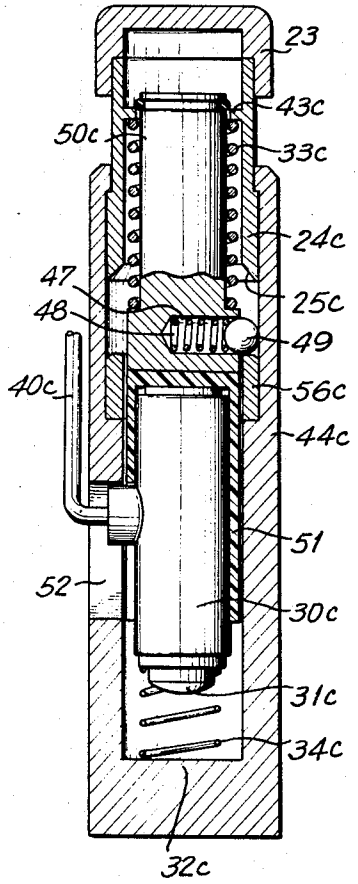


Fig. 6

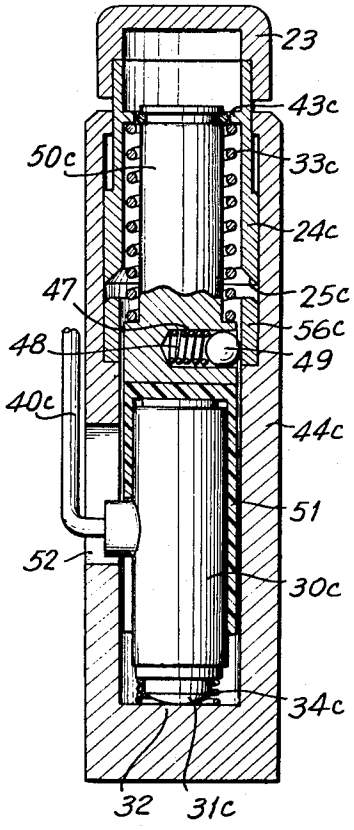


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Fig. 7

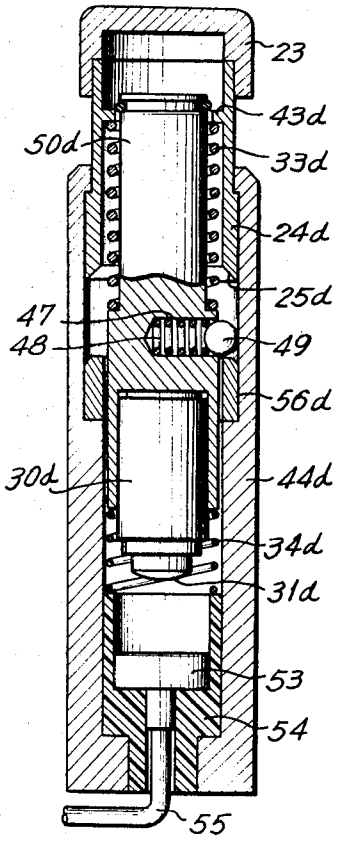
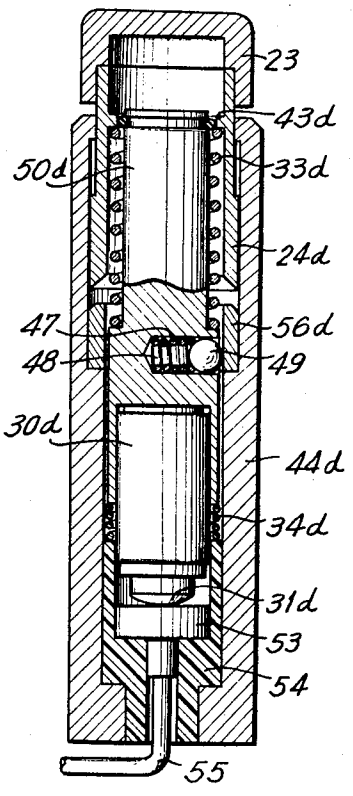



Fig. 8

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United States Patent Office 3,540,823 Patented Nov. 17, 1970



3,540,823

# PIEZOELECTRIC SPARK GENERATOR

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Filed May 28, 1968, Ser. No. 732,594
Claims priority, application Japan, Mar. 28, 1968, 43/19,751
Int. Cl. F23g 7/12
U.S. Cl. 431—255 9 Claims

## ABSTRACT OF THE DISCLOSURE

A structure for generating a spark with a piezoelectric means. The structure is used in conjunction with an electrical circuit which has a pair of electrodes which are spaced from each other to define the spark gap. A stationary impact means coacts with a movable piezoelectric means to be engaged by the latter, and a drive means coacts with the movable piezoelectric means to drive it into impact engagement with the stationary impact means. Thus, by connecting the piezoelectric means into the electrical circuit at least at the instant of impact with the impact means the piezoelectric means will provide between the electrodes a potential difference great enough to create a spark across the gap between the electrodes.

## BACKGROUND OF THE INVENTION

The present invention relates to piezoelectric spark generation.

The invention relates in particular to lighters, such as cigarette lighters, where an ignitable fuel is ignited by a spark derived from a piezoelectric structure.

Devices of this latter general type are already known. Thus, there are known cigarette lighters where a hammer or other impact element is driven into impact engagement with a piezoelectric structure to generate from the latter an electrical voltage sufficiently great to create a spark across the gap between a pair of electrodes forming part of an electrical circuit in which the piezoelectric structure is located. These known devices, however, cannot always be made as small as desired and of a weight which is desirably small. The primary reason for these latter limitations in the conventional constructions resides in the fact that the impact element requires a certain mass and must be driven with a certain force into engagement with the piezoelectric structure in order to generate the required potential difference between the electrodes which define the spark gap. Moreover, these conventional constructions are relatively complex so that the manufacturing and selling costs thereof are undesirably high.

## SUMMARY OF THE INVENTION

It is accordingly a primary object of the present invention to provide a piezoelectric spark generating structure which will avoid the above drawbacks.

It is particularly an object of the present invention to provide a lighter which will avoid the above drawbacks.

Thus, it is the object of the present invention to provide a piezoelectric spark generating structure which is of a desirably small size, so that in the case of a cigarette lighter, for example, the device can easily be carried about on the person.

Also, it is an object of the invention to provide a device of the above type which is of relatively light weight, so that the device can conveniently be carried in a pocket, for example.

In particular, it is an object of the invention to provide a device of the above type which does not require a relatively heavy impact element to be driven with relatively large force, so that through this construction not only is the weight of the structure reduced but in addition the force required to operate the structure can also be reduced.



An additional object of the invention is to provide a piezoelectric spark generation structure which will operate in a more positive manner than conventional structures so as to achieve an improved ignition of a combustible fuel or the like.

Thus, it is a more general object of the invention to provide a device of the above type which is of an exceedingly simple construction enabling both the manufacturing and the selling costs to be reduced.

According to the invention, there is provided in combination with an electrical circuit which has a pair of electrodes between which a spark is to be generated, a stationary impact means, a movable piezoelectric means, and a drive means for driving the movable piezoelectric means into impact engagement with the stationary impact means. Thus, by connecting the piezoelectric means into the electrical circuit at least at the moment of impact with the impact means, the piezoelectric means will provide between the electrodes a potential difference great enough to generate a spark therebetween.

Thus, the above objects are achieved, according to the present invention, primarily by a fundamental improvement in the relationship between the piezoelectric means and the impact means which have an impact engagement with each other. With the present invention, instead of providing a stationary piezoelectric means against which an impact means is driven, the piezoelectric means itself is driven so that advantage is taken of the weight of the piezoelectric means. In this way all that is required is a stationary impact means to stop the movement of the piezoelectric means, and consequently the impact means of the invention can be made much smaller than conventional impact means. Moreover, with conventional structures reliance can be made only on the impact of the movable impact member against the piezoelectric element, in order to achieve the required voltage. In contrast, however, with the present invention advantage can be taken not only of the impact force but also of the momentum of the piezoelectric element itself which due to the sudden stop of the movement thereof creates from this momentum also the additional pressure resulting in the generation of the required voltage by the piezoelectric means. In this way a more positive and more reliable spark generation is achieved.

In the case of a cigarette lighter, the moment of impact of the movable piezoelectric means with the stationary impact means is coordinated with the release of the ignitable fuel so that the spark will have access to the fuel to ignite the latter and provide the required flame. Since no particular mass is required for the impact means itself, inasmuch as the piezoelectric means provides the required movable mass with the present invention, the impact means can be of an extremely small size, as compared to conventional impact elements, and may in fact form a rigid part of a lighter housing, for example. As a result the entire lighter can be made of a weight which is less than has heretofore been possible, and because of the more positive ignition achieved by the moving piezoelectric means it is possible to provide the required spark with a driving force which may be smaller than that which was heretofore required to drive an impact mass into engagement with a stationary piezoelectric structure. Therefore a lighter which incorporates the features of the present invention can be rendered more easily operable than a conventional lighter.

## BRIEF DESCRIPTION OF DRAWINGS

FIG. 1 is a partly schematic sectional elevation of one embodiment of a lighter according to the invention;

FIG. 2 shows part of the structure of FIG. 1 in a different position;

FIG. 3 is a sectional elevation of another embodiment of a spark-generating structure of the invention;

FIG. 4 shows the parts of FIG. 3 in a different position;

FIG. 5 shows a third embodiment of a spark-generating structure of the invention;

FIG. 6 shows the structure of FIG. 5 in a different position;

FIG. 7 is a sectional elevation of yet another embodiment of a spark-generating structure of the invention; and

FIG. 8 shows the structure of FIG. 7 in a different position.

## DESCRIPTION OF PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, the lighter illustrated in FIG. 1 includes a housing-frame unit **11** comprising an outer shell and an inner frame structure carried thereby. Within this unit **11** is a fuel tank **12** which, as viewed in FIG. 1, is situated to the left of the piezoelectric spark generating structure of the invention. This fuel tank **12** is provided with an injection valve **13** through which fuel may be introduced into the tank **12** in a well known manner, this valve **13** having a passage through which air can be removed from the interior of the tank **12** in a known manner. A tube **14** for the gaseous fuel communicates with the interior of the tank **12** and at its upper end carries a burner nozzle **15**. When the nozzle **15** is in the lower position thereof shown in FIG. 1, the nozzle is closed in a known manner, whereas when the nozzle **15** is raised to an operating position, the burner nozzle **15** is open and the ignitable gas can escape from the interior of the tank **12** through the tube **14** and the open burner nozzle **15**.

A manually operable means is provided for displacing the burner nozzle **15** from its lower closed position shown in FIG. 1 to its upper open position, and this manually operable means includes a lever **16** fulcrummed at **17** at the region of the top of the tank **12** and terminating in a free end portion **18** which extends beneath a portion of the burner nozzle **15** so as to raise the latter to its open position upon clockwise turning of the lever **16**, as viewed in FIG. 1. Within the upper portion of the pipe or tube **14** is located an unillustrated spring structure which automatically returns the burner nozzle **15** to its lower closed position shown in FIG. 1 while at the same time returning the lever **16** to the position thereof shown in FIG. 1.

The housing-frame unit **11** includes a manually operable lid portion **19** capable of being moved downwardly by the operator, and part of the lid **19** is formed with a projection **22** engaging the lever **16**, so that when the lid **19** is depressed lever **16** will be turned to raise the burner nozzle **15** to its open position. The housing **11** also carries a pivot shaft **21** on which a safety lid **20** is supported for swinging movement, an extension of the safety lid **20** being received beneath the top wall of the lid **19** so that when the latter is depressed by the operator the lid **20** is swung in a clockwise direction about the pivot shaft **21**, as viewed in FIG. 1, so as to uncover the burner. When the manually operable member **19** is released for return to its position of rest shown in FIG. 1, an unillustrated spring acts on the safety lid **20** to return the latter also to the position of rest thereof which is shown in FIG. 1.

The lower surface of the top wall of the manually operable member **19** engages and may be fixed to a cap **23** which is in turn fixed to the top end of a tubular member **24***a* which forms part of a drive means of the invention. The tube or sleeve **24***a* of the drive means is slidable within a hollow cylindrical guide member **44***a*. The top



end of the cylinder **44***a* is provided with an inwardly directed flange engaging an upwardly directed shoulder of the driving tube **24***a* so as to limit the upward movement of the latter in the manner shown in FIG. 1.

The drive means which includes the manually operable means **19**, **23**, **24***a* also includes a spring means **33***a* for storing a driving force, and this spring means **33***a* of the drive means surrounds the upper portion of the piezoelectric means **30***a*, shown in FIG. 1. This upper portion of the piezoelectric means extends into the interior of the driving tube **24***a*. The piezoelectric means **30***a* includes a pair of piezoelectric units situated on opposite sides of and electrically connected with an electrically conductive ring member **35***a*. The pair of piezoelectric units of the piezoelectric means **30***a* are situated in "back-to-back" relation in that like poles thereof are situated directly next to the electrically conductive portion **35***a* and also the opposed like poles are respectively situated at the opposed ends of the piezoelectric units which are distant from each other and distant from the electrically conductive portion **35***a* of the piezoelectric means **30***a*.

As may be seen from FIGS. 1 and 2, the upper and lower exposed surfaces of electrically conductive portion **35***a* of the piezoelectric means **30***a* are respectively covered by layers **41** and **42** of insulating material. The spring **33***a* of the drive means extends between and engages the upper surface of electrically conductive portion **35***a* and an inwardly directed ring **43***a* fixed to the interior of the driving tube **24***a* as by being formed integrally therewith. A return spring **34***a* extends between and engages the lower layer of insulation **42** and an upwardly directed shoulder formed in the interior of the guide cylinder **44***a*.

The driving tube **24***a* of the drive means terminates at its bottom end in a bevelled end surface **25***a*. The right wall portion of guide cylinder **44***a*, as viewed in FIGS. 1 and 2, is formed with an opening through which a sear **26** extends freely into the interior of the cylinder **44***a* for free movement radially toward and away from the axis thereof. A leaf spring **27** is fixed at one end to the exterior of the cylinder **44***a* and at its opposite end to the sear **26** so as to urge the latter inwardly toward the axis of the cylinder **44***a*. The sear **26** is provided at its inner upper corner with an inclined surface **28** matching the inclination of the end face **25***a* to be engaged by the latter. Thus, during downward movement of the driving tube **24**a, the end face **25**a thereof will engage the edge **28** of sear **26** to displace the latter outwardly to the position indicated in FIG. 2. At its lower inner corner, the sear **26** is provided with a tooth **29** for engaging the outwardly projecting portion of component **35***a* beneath the layer of insulation **42** thereof, in the manner shown in FIG. 1, in order to prevent downward movement of the piezoelectric means **30***a* as long as the tooth **29** remains in the position shown in FIG. 1. Thus, the sear assembly forms a releasable holding means for releasably holding the piezoelectric means **30***a* in the position shown in FIG. 1 in opposition to the force which is stored in the spring **33***a* of the drive means during downward movement of the driving tube **24***a* by the operator. At its lower portion, the guide cylinder **44***a* is formed with an inner cylinder portion **45** for guiding the piezoelectric means **30***a* during its downward movement, so that this part of the structure forms a guide means for the piezoelectric means **30***a*.

In order to achieve from the conductive ring portion **35***a* of the piezoelectric means a high voltage generated due to the instantaneous stopping of the downward movement thereof, upon engagement of the downwardly driven piezoelectric means **30***a* with the impact means **32***a* formed by the lower end wall portion of the cylinder **44***a*, a current-collecting element **36***a* is provided in the form of a stationary contact member carried by the cylinder **44***a* at one side thereof at a location where it

will engage the exposed side surface of conductive portion 35*a* at the instant of impact which is shown in FIG. 2. The piezoelectric means 30*a* has a lower impact end 31*a* for engaging the impact means 32*a* which is stationary. The contact 36*a* is insulated from the guide cylinder 44*a* and is electrically connected with a conductor 40*a* which electrically connects the contact 36*a*, via a resistor 39, to a stationary electrode 37 of the electrical circuit in which the piezoelectric means 30*a* becomes located at the instant of impact shown in FIG. 2. The upper discharge tip 38 of the burner nozzle 15, through which the combustible gas issues, forms the other electrode of this electrical circuit, and when the manually operable means 19, 22 has been displaced downwardly to a position which will locate the driving tube 24*a* at the elevation of FIG. 2, the lever 16 has been turned by this manually operable means in a clockwise direction from the position of FIG. 1 to a position where the movable electrode 38 formed by the burner nozzle tip is located close enough to the stationary electrode 37 to define with the latter the gap across which the spark will jump to ignite the fuel, this spark being created by the potential difference between the electrodes 37 and 38 resulting from impact of the movable piezoelectric means 30*a* against the impact means 32*a*. The electrical circuit in which the piezoelectric means 30*a* becomes located is constituted by the piezoelectric means itself, including its conductive portion 35*a*, the contact 36*a*, the conductor 40*a*, the resistor 39, and the stationary electrode 37, the spark gap, the movable electrode 38, and the ground formed by the metallic components of the lighter which extend between the electrode 38 and the impact means 32*a*.

Thus, assuming that the required fuel, such as liquefied butane, has been inserted into the tank 12, then the ignition of the lighter is very simply brought about by depressing the element 19. When this lid 19 is depressed by the operator, the movement of the lid is transmitted through the cap 23 to the driving tube 24*a* which compresses the spring means 33*a* of the drive means so as to store the driving force in the spring means 33*a*. The compression of the spring means 33*a* takes place by downward movement of the ring 43*a* with respect to the piezoelectric means 30*a* which is maintained in the position of FIG. 1 by the releasable holding means 26, 27. During the downward movement of the lid 19 of the manually operable means, the safety lid 20 is turned to its open position and the projection 22 turns the lever 16 so as to raise the burner nozzle 15 to its open position.

When the manually operable member 19 has been fully depressed, the driving tube 24*a* reached its lowest position where the spring means 33*a* is fully compressed so that the force required to drive the piezoelectric means 30*a* is stored in the spring 33*a*. At this moment the bevelled end face 25*a* at the bottom end of driving tube 24*a* engages the inclined surface 28 of the sear 26 to push the latter in opposition to the spring 27 outwardly to the position shown in FIG. 2, and in this way the tooth 29 of the sear is displaced from beneath the ring portion 35*a* so that the piezoelectric means 30*a* is suddenly and forcefully driven downwardly by the expanding spring means 33*a* until the impact end 31*a* of the piezoelectric means has impact engagement with the stationary impact means 32*a*, thus generating a high potential difference between the electrodes 37 and 38. The parts are shown at the instant of impact in FIG. 2. At this instant when the high voltage is generated by the piezoelectric means 30*a*, the conductive portion 35*a* thereof is in engagement with the contact 36*a*. Therefore, the electrical circuit which includes the contact 36*a*, the conductor 40, the resistor 39, the electrodes 37 and 38 and the spark gap therebetween, and the ground formed by the housing-frame 11 of the lighter is connected on the one hand to a circuit portion which includes the impact means 32*a* and the impact end 31*a* of the piezoelectric means and on the other hand another circuit portion which includes the ring 43*a* and the spring 33*a* itself. The spark which is generated across the gap between the electrodes will ignite the gaseous fuel issuing from the burner nozzle.

After ignition, when the operator releases the lid 19, the return spring 34*a* will expand from the position of FIG. 2 into the position of FIG. 1, so as to return the piezoelectric means 30*a* back to its initial position. The spring 34*a* is of course weaker than the spring 33*a* and is compressed from the position of FIG. 1 into the position of FIG. 2 during the downward movement of the piezoelectric means by spring 33*a*. As the return spring 34*a* expands back toward the position of FIG. 1, the upper portion of conductive ring 35*a*, at its upper insulating covering 41*a*, engages the lower inclined surface of the tooth 29 to displace the latter and the sear 26 outwardly beyond the position shown in FIG. 2 while the conductive portion 35*a* rides upwardly past the tooth 29 until the latter snaps beneath the insulation 42 when the parts have again reached the position of FIG. 1. This upward movement is limited by engagement of the upwardly directed shoulder at the exterior of the driving tube 24*a* with the inwardly directed flange at the top end of the guide cylinder 44*a*. Thus, all of the components return to their initial positions, the burner nozzle 15 being retracted downwardly to its closed position shown in FIG. 1, and the lighter is ready for the next operation.

As is apparent from the above description, with the structure of the present invention the high voltage generated by the piezoelectric means 30*a* by conventional manual operation of a lighter, for example, is brought about not by driving an impact element, such as a hammer or the like, with a sufficient momentum so that due to the mass of the impact element it suddenly stops its movement upon impact with a fixed piezoelectric means. Instead, with the structure of the invention it is the piezoelectric means itself which is driven into impact with a stationary part of the lighter which forms at this stationary part the stationary impact means which will stop the movement of the piezoelectric means to achieve the required high voltage. It is therefore unnecessary with the structure of the invention to provide a movable impact member of the mass required to achieve the impact force necessary to generate the required voltage from a stationary piezoelectric means. Instead it is the piezoelectric means itself which serves to produce the impact energy required for generation of the high voltage. The elimination of a movable impact means of the required mass and volume thus makes it possible to provide a lighter which is smaller in size, lighter in weight, and therefore more convenient to carry about and less expensive to construct. Inasmuch as with the structure of the invention it is the moving piezoelectric means itself which brings about the required impact, the impact is carried out in a more direct manner resulting from the momentum of the particles of the piezoelectric means itself, so that a more positive voltage generation is brought about than with a construction where the piezoelectric means is stationary. In the design of a device such as the lighter shown in FIG. 1, the reduction in length due to the elimination of the impact member makes the design of the structure very easy to carry out in any desired manner. The springs which are required can be very easily selected and need not have the force which would be required for the driving of an impact mass into engagement with a stationary piezoelectric means, so that the lighter of the invention is easier to operate. Thus, as a result of the features of the invention, it becomes possible to provide a lighter which functions in a superior manner, which can be given almost any desired configuration and appearance, and which can be manufactured at a lower cost than conventional lighters.

The embodiment of the invention which is illustrated in FIGS. 3 and 4 provides an improvement in the struc-

ture for guiding the piezoelectric means during its downward movement and for maintaining the parts in proper relationship with respect to each other after ignition and upon return to the starting position. FIGS. 3 and 4 show only the drive means, piezoelectric means, impact means, and guide means, as well as the electrical connection of the piezoelectric means into the electrical circuit. Otherwise the structure is the same as that of FIG. 1.

With the embodiment of FIGS. 3 and 4, the guide cylinder **44***b* is provided in its interior with an insulating sleeve **46** so as to prevent a short-circuit between the conductive portion **35***b* of the piezoelectric means **30***b* and the guide cylinder **44***b* at the instant of impact when the moving piezoelectric means **30***b* generates a high voltage. The insulating sleeve **46** also serves to guide the piezoelectric means **30***b* during its movement so as to form the guide means of this embodiment, and this insulating sleeve **46** directly carries the contact **36***b* which is connected by way of the conductor **40***b* into the electrical circuit described above.

With the embodiment of FIGS. 3 and 4, a cylindrical body **50***b* extends into the interior of the driving tube **24***b* so as to hold the piezoelectric means **30***b*, which extends into a cylindrical bore at the lower end region of the body **50***b*, this body **50***b* moving at all times together with the piezoelectric means **30***b*.

This body **50***b* is formed with a radial bore **47** for receiving the releasable holding means which in this case includes a spring **48** situated in the bore **47** and acting upon a rotary ball member **49**. In the position of the parts shown in FIG. 3, the ball member **49** of the releasable holding means is urged by the spring **48** against the inner surface of the guide cylinder **44***b*, and at this time the ball member **49** engages the top end of a ring **56***b* which is seated on the top end of the insulating sleeve **46**. Thus, the ring **56***b* engages the ball member **49** to prevent downward movement thereof from the position shown in FIG. 3 and because the ball member **49** extends into the bore **47** the body **50***b* and the piezoelectric means **30***b* also cannot move downwardly from the position of FIG. 3. Therefore, when the parts are at rest the ball member **49** is urged by the spring **48** against the inner surface of the cylinder **44***b* and the ring **56***b* prevents downward movement of the ball member **49**.

However, when the driving tube **24***b* reaches its lowest position, the inclined surface **25***b* thereof engages the ball member **49** to push it inwardly into the bore **47** in opposition to the spring **48**. Until the ball member **49** is thus displaced inwardly, the inner ring **43***b* of the driving tube **24***b* will compress the spring means **33***b* of the drive means of this embodiment so as to store the driving force in the spring means **33***b*. When the ball member **49** is pushed into the bore **47** in opposition to the spring **48** by the surface **25***b* of the driving tube **24***b*, the compressed driving spring **33***b* is capable of expanding, in opposition to the force of the weaker return spring **34***b*, the ball member **49** being displaced inwardly beyond the holding ring **56***b* by the surface **25***b*. As a result the unit formed by the body **50***b* and the piezoelectric means **30***b* will be driven downwardly to generate the high voltage in the manner described above upon impact between the impact end **31***b* of the piezoelectric means **30***b* with the stationary impact means **32***b*.

During the return movement of the parts from the impact position shown in FIG. 4 back to the starting position shown in FIG. 3, by the expanding return spring **34***b*, the rotary ball member **49** rolls along the inner surface of the cylindrical ring **56***b* and thus does not provide any substantial resistance to the return of the parts to their initial position. Thus, when the upwardly directed shoulder at the exterior of the driving tube **24***b* engages the inwardly directed flange at the top end of the guide cylinder **44***b*, the ball member **49** will again have the position shown in FIG. 3 where it engages the upper surface of the stop ring **56***b*, so that the driving force can again be stored in the spring **33***b* during downward movement of the cap **23** and the driving tube **24***b* therewith.

With the embodiment of the invention which is illustrated in FIGS. 5 and 6, the parts correspond to those shown in FIGS. 3 and 4 and are used with the remaining components shown in FIG. 1. However, with this embodiment a more positive generation of the high voltage is achieved. Because of the fact that the piezoelectric means itself moves according to the present invention, in order to achieve the required voltage electrical connections different from those required for a conventional stationary piezoelectric means are provided. In the leading of the generated power from a movable member to a stationary electrode, electrical insulation must be fully assured because of the high voltage achieved by the piezoelectric means. Otherwise short-circuiting or leakage will result.

Thus, with the embodiment of FIGS. 5 and 6, the piezoelectric means **30***c* is covered at its exterior surface with a layer of insulation of sufficient thickness. The body **50***c* which corresponds to the body **50***b*, has a lower portion **51** made of insulating material and receiving the piezoelectric means **30***c* so as to prevent electric discharge to the guide cylinder **44***c*. The piezoelectric means **30***c* of this embodiment is also formed of a pair of piezoelectric units arranged in back-to-back relation, as described above. However, in this case there is no conductive ring portion **35***a* or **35***b* which is required to engage a stationary contact **36***a* or **36***b* at the instant of impact. Instead an insulation-covered flexible conductor **40***c* is directly connected to the centrally positioned like poles of the piezoelectric units of the piezoelectric means **30***c*, and the flexible conductor **40***c* moves together with the piezoelectric means. For this purpose the guide cylinder **44***c* is formed with an elongated guide slot **52** whose length is sufficiently great to provide the required axial movement of the flexible conductor **40***c* at its end which is connected with the piezoelectric means **30***c*. Thus, with this embodiment the required high voltage is obtained from the piezoelectric means **30***c* in a more direct manner. By providing a flexible conductor **40***c* as shown in FIGS. 5 and 6 directly connected to the piezoelectric means, the required electrical charge is delivered to the discharge electrodes with a reduced circuit resistance and without any hindrance in the operation of the components. The spring **34***c* returns the parts to their initial position shown in FIG. 5, while the impact end **31***c* of the piezoelectric means **30***c* engages the stationary impact means **32***c* to achieve the required voltage as well as to provide the ground connection referred to above. An unillustrated part of the body **50***c* directly engages the top end of the piezoelectric means **30***c*, through the insulation thereof, so as to provide the other ground connection through the body **50***c*, the spring **33***c*, and the ring **43***c* of the driving tube **24***c* which engages the top end of the spring **33***c*. The releasable holding means **47**, **49** of this embodiment is the same as that of FIGS. 3 and 4 and coacts with the stop ring **56***c* in the manner described above.

With the embodiment of FIGS. 7 and 8, instead of a pair of piezoelectric units arranged in back-to-back relation to form the piezoelectric means, only a single piezoelectric unit is utilized. Thus, with the embodiments of FIGS. 1–6 the circuit includes the ground connections between the impact end of the piezoelectric means and the stationary impact means and between the driving tube and the upper end of the piezoelectric means through the drive spring. However, a different circuit is provided with the embodiment of FIGS. 7 and 8 where only one piezoelectric unit is present. With the embodiment of FIGS. 7 and 8, the part of the circuit which is formed by the impact end **31***d* of the piezoelectric means **30***b* is insulated. Thus, there is no ground connection at this part of the circuit with the embodiment of FIGS. 7 and 8. However, the part of the circuit provided at the top end of the

piezoelectric means **30***d* is indeed a ground connection of the type used in the other embodiments. With the embodiment of FIGS. 7 and 8 there is an impact means **53** which is stationary and which forms the part of the electrical circuit which is insulated and which coacts with the bottom impact end **31***d* of the piezoelectric means **30***d*. The stationary impact means **53** is insulated from the guide cylinder **44***d* by an insulating tube **54**. With this embodiment the guide tube or cylinder **44***d* forms an integral part of the housing-frame structure **11** of FIG. 1. The lower wall of the housing shell is spaced sufficiently beneath the guide cylinder **44***d* so as to accommodate the lower end portion of the conductor **55** which corresponds to the conductors **40***a*–**40***c* referred to above. Thus, this conductor **55** is directly connected with the stationary impact means **53**. The opposite pole of the piezoelectric means **30***d* at its upper end, as viewed in FIGS. 7 and 8, is maintained in contact with the body **50***d* which is made of a conductive metal and which is grounded through the spring **33***d* and the ring **43***d* of the driving tube **24***d*. With this embodiment the remaining components operate in the manner described above, the surface **25***d* coacting with the ball member **49** to release the driving structure after the driving force has been stored in the spring **33***d*, and the returning spring **34***d* expanding from the position of FIG. 8 into that of FIG. 7 to return the parts to their initial position.

Thus, in all of the embodiments of the invention described above and illustrated in the drawings, the advantages derived from a movable piezoelectric means and a stationary impact means are readily apparent. Of course, other constructions utilizing a movable piezoelectric means and a stationary impact means are possible.

What is claimed is:

**1.** For use in the generation of a spark across the gap between a pair of electrodes of an electrical circuit, stationary impact means, movable piezoelectric means, and driving means coacting with said piezoelectric means for driving the latter into engagement with said impact means, said piezoelectric means when connected to the electrical circuit providing upon impact with said impact means a potential difference between said electrodes great enough to create a spark across the gap between said electrodes, and guide means having a generally upright substantially vertical position during use and orienting and guiding said movable piezoelectric means for downward movement by said drive means, said guide means being in the form of a tubular enclosure in which said piezoelectric means is housed and said drive means extending into said enclosure and being situated over said piezoelectric means for driving the latter downwardly, said stationary impact means being situated at the lower end region of said guide means and extending across and closing the interior thereof so as to be situated in the path of movement of a lower impact end of said piezoelectric means to be engaged thereby for terminating the downward driving of said piezoelectric means by said drive means.

**2.** The combination of claim **1** and wherein said piezoelectric means includes a pair of piezoelectric units and electrically conductive member situated between and electrically connected with said units, said electrically conductive member being connected to the electrical circuit only at the moment of impact of said piezoelectric means with said impact means.

**3.** The combination of claim **1** and wherein said piezoelectric means includes a single piezoelectric unit, said impact means being electrically conductive and coacting with said piezoelectric means when the latter engages said impact means to connect said piezoelectric means into the circuit upon impact of said piezoelectric means with said impact means.

**4.** The combination of claim **1** and wherein said drive means includes a spring means coacting with said piezoelectric means for driving the latter toward said impact means when a driving force is stored in the said spring means, spring-operating means coacting with said spring means for storing a driving force therein, and releasable holding means coacting with said piezoelectrc means for releasably holding the latter against movement toward said impact means while said spring-operating means acts on said spring means to store the driving force therein, said releasable holding means responding automatically to the storing of the driving force in said spring means by said spring-operating means for releasing said piezoelectric means to be driven by said spring means into impact engagement with said impact means when the driving force has been stored in said spring means by said spring-operating means.

**5.** The combination of claim **4** and wherein said spring-operating means is manually operable.

**6.** The combination of claim **1** and wherein said lower impact end has a convex curvature.

**7.** The combination of claim **1** and wherein said piezoelectric means includes an exposed electrically conductive portion which moves with said piezoelectric means, and a stationary electrical contact forming part of the electrical circuit and situated next to and engaging said exposed electrical conductive portion of said piezoelectric means when the latter has engaged said impact means, to connect said piezoelectric means into the circuit upon engagement with said impact means.

**8.** The combination of claim **1** and wherein a flexible electrical conductor which forms part of said circuit is permanently connected with said piezoelectric means for movement therewith.

**9.** For use in the generation of a spark across the gap between a pair of electrodes of an electrical circuit, stationary impact means, movable piezoelectric means, and drive means coacting with said piezoelectric means for driving the latter into engagement with said impact means, said piezoelectric means when connected to the electrical circuit providing upon impact with said impact means a potential difference between said electrodes great enough to create a spark across the gap between said electrodes, said impact means, piezoelectric means, and drive means forming together with said electrical circuit and electrodes part of a lighter, said drive means being manually operable and one of said electrodes being stationary, the lighter including a movable burner nozzle movable between a closed position distant from stationary electrode and an open position adjacent said stationary electrode and defining the spark gap therewith, the burner nozzle itself forming the other of the electrodes, and manually operable means coacting with said drive means and nozzle for actuating said drive means to provide for driving of said piezoelectric means into impact engagement with said impact means and also coating with said burner nozzle for displacing the latter from its closed to its open position adjacent said stationary electrode to situate said burner nozzle in its open position where it also acts as said other electrode upon impact of said piezoelectric means with said impact means, a housing-frame unit enclosing the elements of the lighter, and a fuel tank carried by said housing-frame unit for supplying fuel to said nozzle when the latter is displaced to its open position.

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U.S. Cl. X.R.

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