July 22, 1969 L. STEINKE ET AL 3,457,461

PIEZOELECTRIC IGNITER FOR GASEOUS FUELS OR THE LIKE

Filed Feb. 7, 1968 2 Sheets-Sheet 1

FIG. 2a

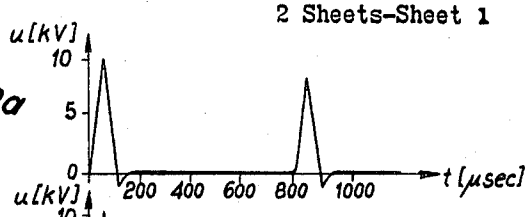


FIG. 2b

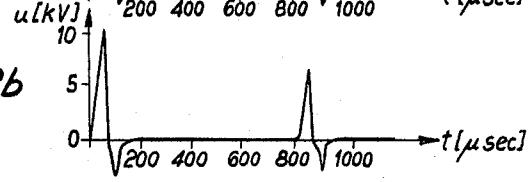


FIG. 1

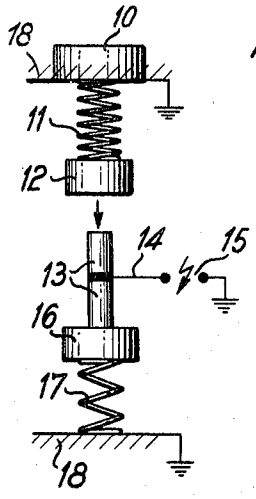


FIG. 4b

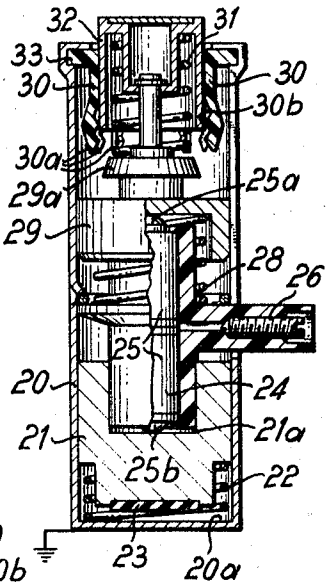


FIG. 3

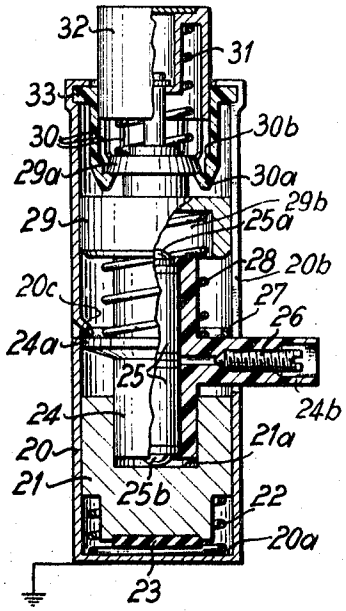
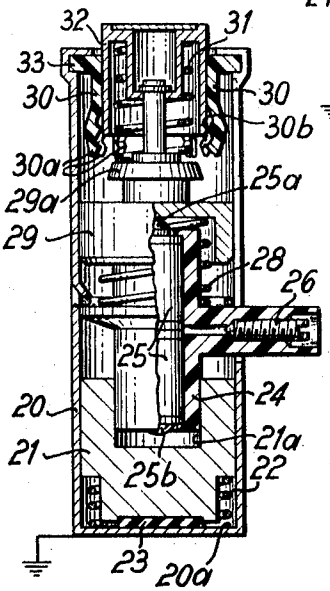


FIG. 4a



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PIEZOELECTRIC IGNITER FOR GASEOUS FUELS OR THE LIKE

Filed Feb. 7, 1968 2 Sheets-Sheet 2

FIG. 5

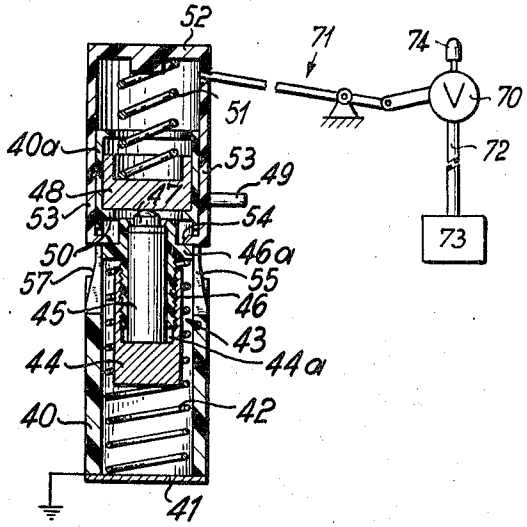


FIG. 6a

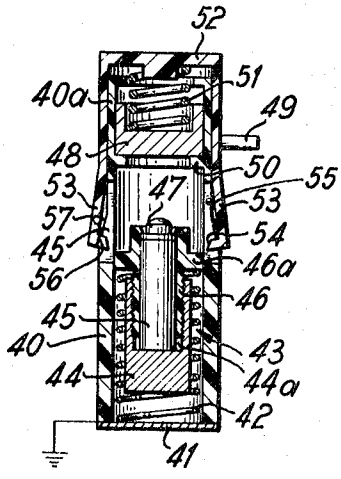
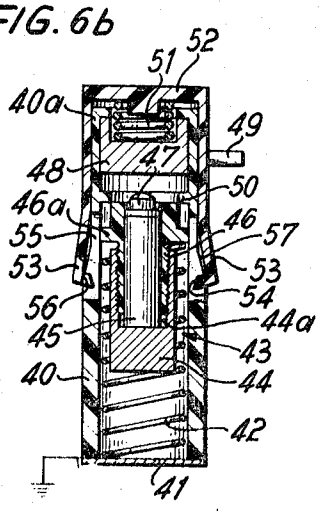


FIG. 6b



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PIEZOELECTRIC IGNITER FOR GASEOUS FUELS OR THE LIKE

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Filed Feb. 7, 1968, Ser. No. 703,587
Claims priority, application Germany, Feb. 22, 1967, B 91,319
Int. Cl. F23q 3/00
U.S. Cl. 317—81 14 Claims

ABSTRACT OF THE DISCLOSURE

A piezoelectric igniter for use in lighters or gas ranges comprises a housing accommodating a reciprocable striking member which can be biased by a first spring to move toward an anvil and to thus cause one or more piezoelectric elements to impart to the anvil a blow and to cause the anvil to stress a return spring which causes the anvil to recoil and to impart a blow to the piezoelectric element. Each blow brings about a change of mechanical stress in the piezoelectric element resulting in a potential difference high enough to cause the discharge of sparks across a spark gap which is electrically connected with the piezoelectric element. The spark gap is adjacent to a burner and a valve opens to admit gaseous fuel to the burner in response to depression of a knob which causes the first spring to store energy prior to propelling the striking member toward the anvil.

The piezoelectric element or elements can be connected with the striking member or they may be installed in the housing adjacent to the anvil in the path of movement of the striking member.

CROSS-REFERENCE TO RELATED APPLICATION

The piezoelectric igniter of our present invention constitutes a modification of the igniter which is disclosed in the copending application Ser. No. 703,760, filed Feb. 7, 1968, by Leo Steinke et al. and assigned to the same assignee.

BACKGROUND OF THE INVENTION

The present invention relates to piezoelectric igniters, and more particularly to improvements in piezoelectric igniters which may be utilized for ignition of flammable gaseous fuels in gas ranges, table lighters or the like.

U.S. Patent No. 3,200,295 discloses a piezoelectric igniter for use in lighters wherein a change in mechanical stressing of a piezoelectric element causes the discharge of a single spark across a spark gap. The spark gap is adjacent to a burner and the discharge of a spark causes ignition of pressurized gaseous lighter fuel. Such igniters are satisfactory for ignition of readily flammable gases but are not suited for use in gas ranges which burn certain types of less readily flammable gaseous fuels, such as butane, natural gas and others. If the combustible mixture adjacent to the spark gap is too lean or too rich, a single spark is often insufficient to insure ignition.

Another piezoelectric igniter is disclosed in Austrian Patent No. 241,008. This igniter comprises a lever which can transmit to the piezoelectric element a stress in the range of 300–500 kp. A drawback of such igniters is that they are too bulky and too complicated for use in certain types of appliances. Furthermore, the stresses transmitted to the piezoelectric element vary within a wide range and their magnitude depends on the skill and strength of the manipulator so that they are not reliable for ignition of certain gaseous fuels.

SUMMARY OF THE INVENTION

It is an object of our invention to provide a piezoelectric igniter which is equally useful and reliable for ignition of readily flammable as well as hard-to-ignite substances, particularly for ignition of various types of gaseous fuels including pressurized gaseous lighter fuel, butane and natural gas.

Another object of the invention is to provide a piezoelectric igniter which can be connected with a spark gap to produce several series or sequences of sparks and to thus insure reliable ignition of less readily flammable fuels.

An additional object of the invention is to provide an igniter wherein the piezoelectric means is invariably subjected to predictable mechanical stresses and wherein such stresses suffice to insure ignition of nearly all types of gaseous fuels.

Another object of the invention is to provide a piezoelectric igniter which occupies little room, which comprises a small number of simple and inexpensive parts, and which can be manipulated by semiskilled or unskilled persons.

An ancillary object of the invention is to provide a piezoelectric igniter which invariably produces at least two sparks and wherein the interval between the discharge of initial and secondary sparks can be selected with a view to insure reliable ignition of less flammable gaseous fuels.

A concomitant object of the invention is to provide a piezoelectric igniter which can be installed in conventional fuel-consuming apparatus, such as gas ranges, table lighters and many others.

The improved piezoelectric igniter comprises piezoelectric means comprising one or more piezoelectric elements, a spark gap electrically connected in circuit with the piezoelectric means and preferably placed adjacent to a valve for a burner, resilient return means disposed at one side of the piezoelectric means, an anvil located between the resilient means and the piezoelectric means, striking means disposed at the other side of the piezoelectric means, and biasing means operative to propel the striking means toward the anvil so that the piezoelectric means imparts to the anvil a blow and undergoes a first change in mechanical stress resulting in a potential difference between the sides of the spark gap and the discharge of one or more sparks across the spark gap to ignite a readily flammable gaseous fuel which flows through the valve no later than at the time the piezoelectric means strikes against the anvil. The blow imparted to the anvil by piezoelectric means causes the resilient means to store energy and to cause the anvil to recoil or rebound and to impart to the piezoelectric means a blow so that the latter undergoes a second change in mechanical stress resulting in the discharge of one or more additional sparks across the spark gap and in ignition of less readily flammable gases.

The piezoelectric means can be coupled to the striking means to share the movement of such striking means under the action of biasing means. Alternatively, the piezoelectric means may be installed in a housing between the anvil and the striking means so that the striking means first imparts a blow to the piezoelectric means and the latter immediately transmits the blow to the anvil and causes the latter to recoil.

The novel features which are considered as characteristic of the invention are set forth in particular in the appended claims. The improved igniter itself, however, both as to its construction and its mode of operation, together with additional features and advantages thereof, will be best understood upon perusal of the following detailed description of certain specific embodiments with reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic view of essential elements of a piezoelectric igniter which embodies one form of our invention;

FIG. 2*a* is a diagram showing the voltage curve when the igniter is disconnected from a spark gap;

FIG. 2*b* shows the voltage curve when the igniter is connected with a spark gap;

FIG. 3 is an axial sectional view of an igniter for use in gas ranges, the striking member being shown in starting position;

FIG. 4*a* is a similar axial sectional view and shows one position of the anvil of the igniter subsequent to release of the striking member;

FIG. 4*b* shows the anvil of the igniter in another position subsequent to release of the striking member;

FIG. 5 is an axial sectional view of a piezoelectric igniter for use in a lighter, the actuating member of the igniter being shown in starting position;

FIG. 6*a* is a similar sectional view but showing the actuating member in depressed position and the striking member in its normal position; and

FIG. 6*b* shows the actuating member in released position and the striking member in depressed position.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 illustrates schematically the essential components of our igniter. A housing **18** is connected with the ground and accommodates a reciprocable actuating member or knob **10** which can stress a biasing means here shown as a helical spring **11**. The spring **11** can propel a striking member **12** against the upper end of one of two stacked piezoelectric elements **13**. These piezoelectric elements are connected in parallel and their adjoining poles are connected with an electrode **14** which is further connected with one side of a spark gap **15**. The other side of the spark gap **15** is grounded. The lower piezoelectric element **13** abuts against a reciprocable back support or anvil **16** which can be propelled upwardly by a helical return spring **17** connected to the ground by way of the housing **18**. The spring constant of the spring **11** is 0.1 kp./mm. and the spring constant of spring **17** is 0.6 kp./mm. The mass of the striking member **12** is 45 grams and the mass of the anvil **16** is also 45 grams.

The operation is as follows:

In order to produce a series of sparks across the spark gap **15**, the user depresses the knob **10** to stress the spring **11** which causes the striking member **12** to impart to the upper piezoelectric element **13** a blow with an energy of 0.04 mkp. The thus produced pressure impulse is transmitted to the anvil **16** which compresses the return spring **17**. The spring **17** recoils and propels the anvil **16** upwardly so that the latter strikes against the lower piezoelectric element **13** with an energy of about 0.03 mkp. to thus produce in the piezoelectric means a second pressure impulse.

During each such pressure impulse, there develops in the elements **13** a change in mechanical stress including an initial rise and a subsequent decrease in mechanical stress. If the spark gap **15** is disconnected from the piezoelectric elements **13**, the potential difference u varies in a manner as indicated by the curve shown in FIG. 2*a*. Such potential difference is measured at the electrode **14** and is substantially proportional to the pressure in piezoelectric elements **13**. Due to relatively high potential difference and also due to internal and insulation resistance of the igniter, the potential difference goes over into negative during reduction of stresses in piezoelectric elements **13**. This is indicated by such portions of the curve shown in FIG. 2*a* which extend below the abscissa. Time t (in microseconds) is measured along the abscissa and the potential difference u in kilovolts is measured along the ordinate. The self-discharge is compensated for in opposite direction. The peak of the initial voltage impulse is

at about 10 kilovolts. The second voltage impulse develops with a delay of about 0.1–1 millisecond and its shape is similar to that of the initial or primary impulse. However, the peak of the second impulse is lower because the energy with which the anvil **16** strikes against the lower piezoelectric element **13** is less than that with which the striking member **12** imparts a blow to the upper piezoelectric element.

When the spark gap **15** is electrically connected in circuit with the piezoelectric elements **13**, the potential difference varies in a manner as indicated by the curve shown in FIG. 2*b*. The voltage required to produce an initial spark is about 10 kilovolts. Such voltage is reached when the striking member **12** imparts a blow to the upper piezoelectric element **13**, i.e., the discharge of a spark across the gap **15** takes place in response to initial compressive stress upon the piezoelectric elements and the voltage collapses in immediate response to generation of the spark. A potential difference of opposite polarity develops in response to decreasing mechanical stress upon the piezoelectric elements **13** to produce a secondary arc discharge across the spark gap **15** which is ionized during initial or primary discharge. Due to the fact that the spark gap **15** is ionized during the initial discharge of a spark, a voltage of at least .7 kilovolt suffices to effect a secondary discharge. The same procedure is repeated when the anvil **16** imparts a blow to the lower piezoelectric element **13**.

Our invention is based on the recognition that less flammable gases can be readily ignited by employing a spark gap in combination with an igniter which can effect secondary discharges of sparks over an intervel of 0.1–1 millisecond following the initial discharge. The two pressure impulses which develop in response to biasing of the spring **11** and subsequent release of the striking member **12** follow each other with a delay of between 0.5–1 millisecond. Each pressure impulse brings about two rapidly following spark discharges, one in response to a rise and the other in response to a decrease in mechanical stressing of the piezoelectric elements **13**. The electrical energy, which is converted into heat energy at the spark gap **15**, is doubled by employing a pair of parallel-connected piezoelectric elements.

FIGS. 3, 4*a* and 4*b* illustrate the details of a piezoelectric igniter which can be utilized in a gas range or the like to effect ignition of flammable gaseous fuels. This igniter comprises an elongated tubular housing **20** which resembles a cylinder or cartridge and has one of its ends closed by an end wall **20***a*. The housing **20** is grounded and accommodates a cylindrical anvil **21**, an elastic disk-shaped cushion **23** of rubber or the like which is interposed between the lower end face of the anvil and the bottom wall **20***a* and which can be attached to the anvil, and a helical return spring **22** which operates between the bottom wall **20***a* and an external annular shoulder of the anvil. The upper end face of the anvil **21** has a cylindrical recess **21***a* which accommodates the lower end portion of a cylindrical sleeve **24** of insulating material. The sleeve **24** surrounds two stacked piezoelectric elements **25** which are connected in parallel. The high-voltage electrode **26** which is placed between the adjoining ends of the piezoelectric elements **25** extends into a radial nipple **24***b* of the sleeve **24**, and such nipple extends radially through an axially parallel slot **20***b* of the housing **20**. The sleeve **24** has an external ring-shaped projection or collar **24***a* which is guided in the housing **20**. The collar **24***a* forms part of an anchoring device and cooperates with a ring-shaped spring **27** which is engaged by several inwardly extending projections **20***c* of the housing **20**. The collar **24***a* further serves as an abutment for the lowermost convolution of a helical resetting spring **28** which biases a striking member **29** upwardly to the starting position shown in FIG. 3. FIG. 4*a* shows this striking member **29** in its other end position when it imparts a blow to an extension or cap **25***a* at the upper end of the upper piezo-

electric element **25**. The lower end face of the striking member **29** has a recess **29***b* which accommodates one or more convolutions of the resetting spring **28**. The upper portion of the striking member **29** is provided with a substantially disk-shaped flange or head **29***a* of frustoconical outline which can be engaged by the lower end portions or hooks **30***a* of several equidistant elastic retaining claws **30** which serve to yieldably retain the striking member **29** in the starting position shown in FIG. 3. The claws **30** are integral with a mounting ring **33** which is fixedly secured in the upper end of the housing **20**.

The biasing means for the striking member **29** comprises a helical spring **31** having a lower end convolution which abuts against the head **29***a*. The upper convolutions of the spring **31** extend into a depressible actuating member or knob **32** which is guided in the top end wall of the housing **20** and extends into the space between the claws **30**. The mounting ring **33** and its claws **30** preferably consist of synthetic thermoplastic material. Cams **30***b* provided on the claws **30** immediately above the respective end portions **30***a* can be engaged by the lower end face of the knob **32** to thus disengage the end portions **30***a* from the flange or head **29***a* when the spring **31** stores sufficient energy to propel the striking member **29** against the cap **25***a*.

When the knob **32** is depressed (see FIGS. 4*a*, 4*b*) it engages the cams **30***b* and causes the end portions **30***a* to move radially outwardly so that the striking member **29** undergoes strong acceleration in response to the bias of spring **31** which is stressed during initial depression of the knob **32**. The bias of the spring **31** is much stronger than the bias of resetting spring **28** so that the latter cannot prevent rapid acceleration of the striking member **29** and the transmission of a strong blow to the cap **25***a*. The pressure impulse propagates itself through the piezoelectric elements **25** and causes a downward movement of the anvil **21** which stresses the return spring **22**. This is shown in FIG. 4*a*. The anvil **21** recoils because the return spring **22** expands and propels the anvil upwardly so that the latter strikes against an extension or cap **25***b* of the lower piezoelectric element **25**. This is shown in FIG. 4*b*. The anvil **21** then produces a second pressure impulse. The knob **32** is released upon completed rebounding of the anvil **21** so that the resetting spring **28** returns the striking member **29** to the starting position of FIG. 3. The lower end portions **30***a* of the claws **30** engage and retain the flange **29***a* to hold the striking member **29** in such starting position. The manner in which the potential difference varies in response to depression of the knob **32** is the same as described in connection with FIGS. 2*a* and 2*b*.

The igniter of FIGS. 5, 6*a* and 6*b* comprises a prismatic or block-shaped housing **40** of rectangular cross-sectional outline which is adapted to be installed in the decorative case or outer shell of a table lighter. The upper portion **40***a* of the housing resembles a hollow cylinder and the lower end of the housing **40** is closed by a grounded bottom wall **41** of metallic material. The housing **40** consists of synthetic plastic material. The upper side of the end wall **41** is engaged by the lowermost convolution of a helical biasing spring **42** located below an assembly **43** including a metallic striking member **44**, an insulating sleeve **46**, and a piezoelectric element **45** in the sleeve **46**. The parts **45**, **46** are received in a recess of the striking member **44** and the sleeve **46** is threadedly connected with the striking member. The sleeve **46** overlies the top face of the piezoelectric element **45** and carries a centrally located cap or extension **47** which can transmit blows to and by the element **45**. An external projection or collar **46***a* of the sleeve **46** is engaged from below by the topmost convolution of the spring **42**. In addition, the collar **46***a* can slide along the internal surface of the housing **40** to prevent tilting of the assembly **43**.

The top portion **40***a* of the housing **40** accommodates a cylindrical anvil **48** which is connected with a high-voltage electrode **49**. The latter extends from the housing **40**. A return spring **51** biases the anvil **48** downwardly, and this spring **51** also serves as a means for resetting a depressible actuating member or knob **52** which is slidable on and surrounds the portion **40***a* of the housing **40**. When the spring **51** is free to expand, it maintains the anvil **48** in abutment with one or more internal projections or stops **50** of the housing portion **40***a*. These stops **50** may form a continuous internal collar in the housing portion **40***a*. The knob **52** has two elastic claws or tongues **53** which are located diametrically opposite each other, and the lower end portion of each claw **53** is provided with an inwardly extending hook **54**. These hooks extend through longitudinally extending slits **55** of the housing **40** and abut against the top face of the collar **46***a* on the sleeve **46** in the starting position of the knob **52**. Each of the claws **53** is further provided with a cam **56** which cooperates with a cam **57** on the housing **40** to move the respective hook **54** radially outwardly in response to depression of the knob **52**. This is shown in FIGS. 6*a* and 6*b*.

When the user depresses the knob **52**, the end portions **54** of its claws **53** moves the assembly **43** downwardly because the end portions **54** bear against the top face of the collar **46***a*. The spring **42** is compressed and stores energy. As the knob **52** continues to move downwardly toward the end wall **41**, the cams **56** of the claws **53** engage the cam or cams **57** on the housing **40** and cause the end portions **54** to move apart and to be disengaged from the collar **46***a*. This is shown in FIG. 6*a*. The assembly **43** is released and is propelled upwardly in response to expansion of the spring **42** which causes the cap **47** to strike against the underside of the anvil **48**. The piezoelectric element **45** receives a pressure impulse and causes the anvil **48** to move upwardly against the opposition of the return spring **51** which stores energy. This is shown in FIG. 6*b*. The anvil **48** recoils and its lower end face imparts to the cap **47** a blow to produce in the piezoelectric element **45** a second pressure impulse. Such second impulse lags behind the initial impulse by a predetermined interval. When the user releases the knob **52**, the spring **51** expands fully and returns the parts to the positions shown in FIG. 5, i.e., the end portions **54** of the claws **53** come to rest on the top face of the collar **46***a*. The potential difference which develops in response to depression of the knob **52** varies in the same way as described in connection with FIGS. 2*a* and 2*b*. The electrode **49** is connected with one side of a spark gap (not shown) which is adjacent to the orifice of a fuel valve **70** for a burner **74**.

Readily flammable gaseous fuels are ignited in response to the first series of first spark discharges which develop when the piezoelectric means receives a blow from the striking member (FIGS. 3, 4*a* and 4*b*) or when the piezoelectric means strikes against the anvil (FIGS. 5, 6*a* and 4*b*). Ignition of hard-to-ignite gaseous fuels invariably takes place in response to the second series of spark discharges which develop when the anvil recoils. As explained hereinbefore, the second series of discharges follows the first series with a certain time lag. The duration of discharges can be extended in a well known manner by placing the spark gap in series with a resistor or with an inductance. For example, the resistor may comprise an anti-interference cable of high ohmic resistance of the type often used in internal combustion engines.

When the improved igniter is used in a lighter or in connection with a burner in gas range or the like, the knob **32** or **52** may be coupled with and can open a fuel valve prior to discharge of the initial series of sparks. This is shown in FIG. 5 which illustrates an operative connection **71** (e.g. a link train, a gear train or a solenoid) serving to open the valve **70** in response to depression of the knob **52**. The valve **70** is installed in a conduit **72** which supplies gaseous fuel from a source **73** to the burner **74**.

Without further analysis, the foregoing will so fully

reveal the gist of the present invention that others can, by applying current knowledge, readily adapt it for various applications without omitting features which fairly constitute essential characteristics of the generic and specific aspects of our constribution to the art and, therefore, such adaptations should and are intended to be comprehended within the meaning and range of equivalence of the claims.

What is claimed as new and desired to be protected by Letters Patent is set forth in the appended claims.

We claims:

1. A piezoelectric igniter, particularly for flammable gaseous fuels, comprising piezoelectric means; a spark gap electrically connected in circuit with said piezoelectric means; resilient return means disposed at one side of said piezoelectric means; an anvil located between said return means and said one side of said piezoelectric means; striking means disposed at the other side of said piezoelectric means; and biasing means operative to propel said striking means toward said anvil so that said piezoelectric means imparts to said anvil a blow and undergoes a first change in mechanical stress resulting in a potential difference between the sides of and a spark discharge across said gap whereby said anvil causes said return means to storage energy and to propel the anvil against said piezoelectric means so that the latter undergoes a second change in mechanical stress resulting in renewed spark discharge across said gap.

2. An igniter as defined in claim 1, wherein the masses of said anvil and said striking means and the characteristics of said biasing means and said return means are such that the interval between said first and second changes in mechanical stress is in the range of 0.1–1 millisecond.

3. An igniter as defined in claim 1, wherein the mass of said striking means at least approximates the mass of said anvil.

4. An igniter as defined in claim 1, further comprising a housing for said anvil and said return means, said housing having an end wall and said return means comprising spring means located between said anvil and said end wall.

5. An igniter as defined in claim 1, wherein said striking means comprises a metallic member and further comprising an insulating member connecting said piezoelectric means with said metallic member.

6. An igniter as defined in claim 5, wherein said insulating member comprises a sleeve which surrounds said piezoelectric means and is movable with said metallic member.

7. An igniter as defined in claim 1, further comprising actuating means operative to cause said biasing means to store energy prior to propulsion of said striking means toward said anvil.

8. An igniter as defined in claim 7, wherein said actuating means is movable from a starting position and said return means is arranged to return said actuating means to starting position on completed propulsion of said anvil against said piezoelectric means.

9. An igniter as defined in claim 8, further comprising a housing for said anvil, said striking means and said biasing means, said actuating means comprising a reciprocable member movable with reference to said housing and said return means comprising a spring interposed between said actuating means and said anvil.

10. An igniter as defined in claim 9, wherein said housing comprises a tubular portion for said anvil and said reciprocable member of said actuating means is coaxial with and is slidably guided by said tubular portion.

11. An igniter as defined in claim 9, further comprising an insulating member surrounding said piezoelectric means and connected with said striking means, said sleeve having an external projection and said actuating means further comprising a plurality of elastic claws engaging said projection in the starting position of said actuating means so as to move said sleeve and said striking means and to thus cause said biasing means to store energy in response to movement of said actuating means from starting position.

12. An igniter as defined in claim 11, wherein said housing is provided with slits for said claws and with means for disengaging said claws from said projection in response to a predetermined displacement of said actuating means from starting position so that said biasing means is free to dissipate energy and to propel said striking means toward said anvil.

13. An igniter as defined in claim 12, wherein said claws consist of elastomeric material.

14. An igniter as defined in claim 1 for use in combination with a burner having valve means movable between open and closed positions to respectively permit and prevent passage of a gaseous fuel, wherein said spark gap is adjacent to said valve means and further comprising actuating means for effecting propulsion of said striking means toward said anvil at the will of the user, said actuating means comprising means for opening said valve means prior to initial spark discharge across said gap so that said valve means discharges fuel at the time of initial spark discharge.

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VOLODYMYR Y. MAYEWSKY, Primary Examiner

U.S. Cl. X.R.

310—8.7; 315—55; 317—96