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(54) A LIQUEFIED GAS-FUELLED SMOKER'S LIGHTER UTILIZING PIEZOELECTRIC ELEMENTS AS THE IGNITER VOLTAGE GENERATION SOURCE

(71) We, MANSEI KOGYO KABUSHIKI KAISHA, a Japanese Company, of 3035, 1-chome Kamiaoki-cho, Kawaguchi City, Saitama Prefecture, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to smokers' lighters. According to this invention a smokers' lighter comprises a casing, a reservoir for liquified gas fuel, a valve controlling the flow of gas from the reservoir, a burner assembly including a gas passage which terminates in an outlet port, said burner assembly being located in the casing so that the outlet port is substantially coaxial with an opening in the casing, a pair of electrodes each having a portion extending into the gas passage upstream of the outlet port, a piezo-electric generating device adapted to generate a spark between the electrodes, and a member which, when operated, causes deformation of piezo-electric elements in the device and, at substantially the same time, causes the gas valve to open.

Embodiments of our invention are illustrated in the accompanying drawings in which:—

Figure 1 is a front elevational view in partial section of one preferred form of smokers' lighter of the liquified gas fuelled type constructed in accordance with the present invention;

Figure 2 is a side elevational view in section of the lighter illustrated in Figure 1;

Figure 3 is a fragmentary vertically sectional view on an enlarged scale of one preferred form of burner for incorporation in the lighter illustrated in Figures 1 and 2;

Figure 4 is similar to Figure 3, but shows a modified form of burner together with its associated principal parts of the lighter with the latter being shown in elevation on an enlarged scale;

Figure 5 is a fragmentary elevational view in partial section of another modified form of burner;

Figure 6 is similar to Figure 3, but shows a further modified form of burner;

Figure 7 is cross-sectional view of a water-repelling electrode mounting member on the line A—A of Figure 6;

Figure 8 is similar to Figure 7, but shows a modified form of water-repelling electrode mounting member;

Figure 9 is similar to Figure 7, but shows a further modified form of water-repelling electrode mounting member;

Figure 10 is a fragmentary view on an enlarged scale of the intermediate spark gap providing structure shown in Figure 2; and

Figure 11 is a schematic view of the voltage generation circuit.

The lighter illustrated in Figures 1 to 3 of the accompanying drawings comprises a hollow main body or casing 1 and a hollow base mount 2 on which the main body 1 is fixedly mounted and on which it stands vertically when in use. The main body and base mount provide in co-operation the outer sheath structure of the lighter. The hollow base mount 2 includes an inverted frusto-conical section 3, an integral flanged and externally threaded cylindrical section 4, an inverted cup-shaped upper cover member 5 having the downwardly flared peripheral edge and a threaded centre bore 5¹ through which the cylindrical section extends, and a cup-shaped lower cover member 6 having the upwardly flared peripheral edge. The flange of the cylindrical section 4 seats on the top surface of the upper cover member 5 surrounding the periphery of the centre bore 5¹. The main body 1 and base mount 2 are secured together to each other by means of a plurality of set screws 7. Disposed within the upper cover member 5 is an inverted cup-shaped insert member 8 having the outer configuration mating with the inner

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configuration of the inverted cup-shaped upper cover member 5. The insert member 8 has a central threaded bore 8¹ which engages the thread on the periphery of the cylindrical section 4. The insert member 8 is further provided with annular bosses 8¹¹ on the lower or inner surface and each of the bosses is provided with a threaded bore. A connecting member 9 is received in the threaded bore in each of the bosses 8¹¹ of the insert member 8 by means of an externally threaded boss 9¹ of the connecting member. Each of the connecting members 9 is further provided with a threaded central bore 9¹¹ for receiving a set screw 10 which extends through the lower cover member 6 from the bottom thereof into the associated threaded bore 9¹¹ in the connecting member 9. The height of the connecting members 9 is selected so that the opposite peripheral edges of the upper and lower cover members 5 and 6 may provide a space therebetween for the purpose to be described hereinbelow. An annular decorative ring 11 is disposed between the upper and lower cover members 5 and 6 and has a peripheral flange 11¹ at the outer periphery extending outwardly into the space between the upper and lower cover members 5 and 6. A rectangular cross-section chassis 12 extends vertically within the main body 1 and has skirts which extend outwardly substantially at right angles to the respectively associated vertical walls of the chassis and are secured to the lower end of the main body 1 by means of the set screws 7 which also connect the main body and base mount together. Supported within the chassis 12 is a high voltage generation device which employs piezoelectric elements as the high voltage generating source and of which a detailed description will be made hereinbelow. The high voltage generation device generally comprises a support frame structure including an outer frame 13 and an inner frame 13¹ which houses a shoe 14, an eccentric cam 15 having a shaft for applying a pressure on piezoelectric members through a pressure transfer plate 16, a piezoelectric element unit including a pair of opposite series-connected piezoelectric elements 17 and 17 having a terminal plate 18 disposed between adjacent ends and a washer 19 and a wedge 20 located at the end of the element unit remote from the transfer plate 16. The outer frame 13 is fixedly secured to the chassis 12 by means of set screws (only one is shown in Figure 2) and the inner frame 13¹ is fixedly secured to the outer frame by suitable means (not shown). The rotational support shaft of the eccentric cam 15 extends through the opposite sides of the outer frame 13 and is journaled in bearings (not shown) which are in turn suitably supported in the outer frame 13. An operating lever 21 is a snug

fit at its centre on the rotational shaft of the eccentric cam 15 for rocking movement together with the cam shaft. The operating lever 21 supports at one or the upper end an operating member in the form of a roller 22 and the other or lower end of the lever supports a valve manipulation member in the form of a roller 23. As seen in Figure 1, the main body 1 is provided in its one wall with an opening 1¹ and one end wall of the chassis 12 is cut away at the upper end portion so that a lateral thumb piece assembly 24 may be slidably received in the opening and cut away portion of the main body and chassis. The thumb piece assembly 24 comprises an outer block 25, an inner block 25¹ and a stop piece 26 which are integrally secured together by means of set screws. The inner block 25¹ is provided at one upper corner with a notch 25¹¹ for slidably receiving the roller 22 on the operating lever 21. An L-shaped valve operating member 27 pivoted at the lower end to the chassis 12 in a position in which the upper end of the operating member abuts against the lower roller 23 on the lever 21. The lower end of valve operating member 27 encircles the shank of the nozzle 28 underneath the flange on the nozzle shank which is in turn connected to a reservoir 30 for liquefied gas fuel through a conventional spring-loaded valve mechanism including a valve 29 disposed within the reservoir. Thus, when the operating lever 21 is operated so as to pivot the valve operation member 27 in the counterclockwise direction as viewed in Figure 1, the lower end of the operation member 27 is caused to push the nozzle upwardly whereby the fuel flows from the reservoir 30 through the internally disposed valve mechanism and the nozzle to the ignition section of which description will be made hereinbelow. On the other hand, when the lever 21 is allowed to rock so as to cause the valve operation member 27 to pivot in the opposite or clockwise direction, the operation member 27 pushes the nozzle 28, down to close the valve 29 whereby the flow of the fuel from the reservoir 30 is halted. The valve 29 has a gas flow adjusting ring 31 which is fixedly received in a ring retention opening 32 formed by cutting and bending upwardly or inwardly the bottom wall of the chassis 12. The reservoir 30 extends into the main body 1 at its upper end and at its lower end into the sections 3 and 4 of the base mount 2 and is supported in the midsection by means of a resilient member 33 formed of material such as synthetic resin which is retained in the upper inverted frusto-conical section 3 of the base mount 2. Disposed within and in communication with the lower end of the reservoir 30 is a fuel injection valve 34 and the extreme lower end of the reservoir 30

s formed with a projection 35 of non-circular cross-section. A gas flow adjusting knob 36 is fitted snugly on the projection 35 in the raised centre of the lower cover 6 and when the knob 36 is turned in one direction or another so as to cause the reservoir 30 to rotate relative to the gas flow adjusting ring 31 received in the retention opening 32, the flow rate of the gas from the reservoir through the valve 29 and nozzle 28 can be adjusted.

A conductor 37 extends upwardly along the inner wall of the main body 1 and the upper end of the conductor terminates at a point at a small distance from the upper end of the chassis 12 while the lower end is connected to the terminal plate 18. Another conductor 37¹ having one end connected to anode 39 extends downwardly along the inner wall of the main body 1 and terminates short of the upper end of the conductor 37 thereby to provide an intermediate spark discharge gap 38 between the two conductors which gap is surrounded by an insulator 38¹. The above-mentioned anode 39 is suitably and horizontally supported in an electrode mounting member 40 in which a cathode 41 is also suitably and horizontally supported in a position opposite to and spaced from the anode 39. The cathode 41 is connected to a conductor 42 which extends downwardly from the cathode along the inner wall of the main body 1 in opposition to and spaced from the first-mentioned conductor 37¹. The other end of the conductor 42 is connected to the chassis 12. The electrode mounting member 40 is suitably supported in and depends from the top wall of the main body 1 and has a central gas passage *a*. A gas mixing tube 43 is threadably received in the lower portion of the electrode mounting member 40 so as to form an extension of the gas passage *a* and a wire mesh 44 is disposed across the junction between the electrode mounting member and gas mixing tube. A flame spouting nozzle 45 or outlet is received at the upper end of the electrode mounting member 40 in communication with the gas passage *a* thereof. The electrode mounting member 40 has the flared upper end 40¹ which abuts against the inner side of the top wall of the main body 1, under the force of a spring so that the mounting member is prevented from moving upwardly relative to the main body 1. The gas mixing tube 43 is provided with primary air intake bores 46 in the lower portion of the wall thereof and a gas guiding tube 47 is received in the lower portion of the gas mixing tube 43. The gas guiding tube 47 has a constricted lower portion which is slidably received in an opening in the top wall of the chassis 12 and has a threaded end. A connector member 48 is screwed

in this end of the gas guiding tube 47 and the connector member receives at a point below the top wall of the chassis 12 one end of a gas conduit 49. The other end of the gas conduit 49 is connected to the nozzle 28. In other words, the flame spouting nozzle 45, electrode mounting member 40, gas mixing tube 43, gas guiding tube 47 and connecting member 48 are axially aligned with respect to each other so as to provide a unitary burner assembly. The burner assembly is disposed between the top wall of the main body 1 and the top wall of the chassis 12 and is movable against the force in a compression spring 50 surrounding the gas mixing tube 46 and located between the underside of the electrode mounting member 40 and the top wall of the chassis 12. Thus the entire burner assembly is normally urged against the top wall of the main body 1 whereby the relation between the various parts of the ignition device are maintained in a predetermined proper relation.

In operation, when the thumb piece assembly 24, which is normally held in the position shown in Figure 1, is forced inwardly toward the opposite inner wall of the main body 1 by the application of a manual force, the roller 22 is urged in a direction to cause the operating lever 21 and eccentric cam 15 to rock in a clockwise direction as viewed from Figure 1. This rocking movement of the lever 21 and eccentric cam 15 causes the cam to squeeze the piezoelectric elements 17 through the pressure transfer plate 16 to generate a high voltage. The positive polarity of the voltage is conducted through the conductor 37, intermediate spark discharge gap 38 and the conductor 37¹ to the anode 39. The opposite or negative polarity of the voltage is conducted through the chassis 12 and conductor 42 to the cathode 41 whereby sparks are struck across the spark discharge gap provided by the opposite electrodes 39 and 41. Simultaneously, the rocking movement of the lever 21 in the clockwise direction also causes the valve manipulation member 27, which is engaged by the lower roller 23 on the lever 21, to rock in the counter-clock direction thereby the lower end of the member pushes the nozzle 28 upwardly whereupon the pressurized gas flows from the reservoir 30 through the valve 29 and nozzle 28 into the gas conduit 49. The gas conduit 49 conducts the gas to the gas mixing tube 43 where the gas is mixed with the primary air flowing into the gas mixing tube via the primary air intake bores 46. The gas-air mixture rises up to the spark discharge gap between the electrodes 39 and 41 and is ignited by the sparks being struck across the spark discharge gap in the manner mentioned above and flames are dis-

charged from the upper end of the flame spouting nozzle 45.

Figure 3 shows a modified form of burner suitably employed in the lighter shown in Figures 1 and 2 according to the present invention. The burner generally comprises an open-end upper cylindrical section 51, a coaxial open-end lower cylindrical section 52 having the upper end threaded in the lower end of the upper cylindrical section and a bottom member 53 having a constricted upper end fitted snugly in the lower end of the lower cylindrical section 52, and a centre gas intake opening 54. The pair of discharge electrodes 39 and 41 are received in a pair of diametrically opposite bores formed in the walls of the upper section 51 and the electrodes are horizontally disposed in an opposed spaced relationship with their adjacent ends projecting into a gas passage *a* in the upper section so as to provide a spark discharge gap therebetween. The electrode 39 is connected to the negative side of the voltage generation source as shown in Figure 2 and the other electrode 41 is connected to the opposite side of the source. As seen in Figure 3, the anode 41 is received in a suitable insulating member 55 which is in turn received in the bore of the wall of the upper cylindrical section 51. A wire mesh 51*a* is disposed in the junction between the upper and lower cylindrical sections 51 and 52 across the gas passage *a*. The wire mesh 51*a* may be replaced by a porous plate or any other suitable bored element if desired. The lower cylindrical section 52 is provided with primary air intake bores 46¹ and 46² in the wall thereof in the same manner as mentioned in the corresponding part of the embodiment of Figures 1 and 2. Furthermore the bottom member 53 has a depending further constricted extension 53¹ at the bottom thereof and the upper end of the gas conduit 49 is fitted on the extension 53¹. Thus, it will be understood that when the reservoir is opened in the manner as mentioned above in connection with the preceding embodiment, the fuel from the reservoir is discharged from the reservoir, through the valve 29 and nozzle 28 and gas conduit 48 into the gas intake opening 54 in the bottom member 53 into the lower section 52 where the gas is mixed with the primary air flowing into the section 52 via the primary air intake bores 46¹. The gas-air mixture rises up through the lower section 52 and wire mesh 40 into the upper section 51. As the mixture passes through the wire mesh 51*a* the mixture impinges against the mesh so as to generate a turbulent flow in the mixture whereby the gas and air are mixed together fully. The gas-air mixture thus formed then flows upwardly through the upper section of the gas passage *a* and finally reaches

the top of the burner. When a high voltage is applied across the electrodes 39 and 41 in the manner mentioned in connection with the preceding embodiment while the mixture is passing through the passage *a*, sparks strike out in the spark discharge gap between the electrodes 39 and 41 and thus, the gas-air mixture is explosively ignited by the sparks to force out flames which then issue from the upper end of the burner. With the construction of the burner described above, the gas and air can be mixed together to a condition suitable for ignition by the discharge sparks as they pass through the wire mesh 51*a*. Furthermore, the electrodes 39 and 41 can be positively prevented from being contacted by the successive flames whereby the possibility of erosion of the electrodes may be limited to a minimum degree. In addition, the danger of the electrodes being struck by foreign matters is prevented. Otherwise this will have undesirable effects on the function of the discharge spark gap.

Figure 4 shows a further modified form of burner according to the present invention which can positively ignite the gas even when sparks at relatively low discharge voltages are generated. The reservoir 130 of Figure 4 is provided with a second valve 129 and a first valve 129¹ which are adapted to be opened so as to allow the gas to flow out of the reservoir when the nozzle (not shown) is lifted up. A horizontally movable valve operation means 58 is horizontally disposed above the two valves 129 and 129¹ for operating the valves and has first and second valve opening and closing members 60 and 59 each having slots (not shown) of substantial length which encircle and engage the valves respectively. The second valve opening and closing member 59 has a stepped configuration at the bottom, and the second opening and closing member has an upwardly arched portion in the centre of the bottom as shown in Figure 4. The valve operation means 58 is also provided with an ear 58¹ to which a cam 115 is pivoted for pivotal movement in a limited distance. Disposed above said valve operation means 58 is an L-shaped frame member 61 one or vertical arm of which has piezoelectric element unit 17¹ secured thereon and the other or horizontal arm of the frame member has an impact delivery member 62 pivoted. As seen in Figure 4, the impact delivery member 62 is pivoted at the upper end to, and depends from, the free end of the other arm 61 of the frame member. A spring 63 is anchored at one end to the first arm of the frame member 61 and at the other end to the impact delivery member 62 below the pivoted point so as to urge the impact delivery member normally toward the piezoelectric element

nit 17¹. A main gas conduit 149 is connected at the lower end to the second nozzle 128 associated with the second valve 129 and extends along the vertical wall of the main body (not shown). The upper end of the gas conduit 149 first bends at right angles with respect to the vertically extending midsection thereof to extend through an opening in the wall of the burner. In this embodiment the burner consists of an open-ended single cylindrical section 151 and a bottom member 153 having a depending constricted extension 153¹. The extreme upper end of the gas conduit 149 bends at right angles with respect to the horizontal upper section thereof and extends upwardly to open at the open upper end of the burner as the gas nozzle 145. Thus, when the valve operation means 58 is moved in the arrow *x* direction as seen in Figure 4 to a predetermined distance by any suitable means (not shown), the second valve opening and closing member 59 moves along the nozzle 128 in the same direction by means of its slot until the outer or higher portion of the member 59 engages and pushes up the flange on the shank of the associated nozzle. This opens the valve associated with the nozzle 128 and at the same time the first valve opening and closing member 60 is also moved along the associated nozzle 128¹ by means of its slot until the centre arched portion engages and pushes up the flange on the shank of the associated nozzle 128¹ to open the associated valve. When the valves are opened in the manner mentioned above, a portion of the gas is allowed to flow from the reservoir 130 through the second valve, nozzle and gas conduit 149 and is discharged from the gas nozzle 166. At the same time another portion of the gas is allowed to flow from the reservoir, through an auxiliary conduit 149¹ and is discharged into the gas passage *a* in the cylindrical section 151. When the valve operation means 58 is moved in the arrow direction *x* as mentioned above, simultaneously, the cam 115 pivoted to the operation means 58 is moved in the counter-clockwise direction so as to cause the impact delivery member 62 to pivot away from the piezoelectric element unit in the counter-clockwise direction while allowing the spring 63 to store an impacting energy therein. As the operation means 58 is moved in the same linear direction by a further amount, the impact delivery member 62 finally disengages from the cam 115 whereupon the impact delivery member 62 is caused to move rapidly towards the piezoelectric element unit and strikes the piezoelectric elements with a high striking force due to the action of stored energy in the spring 63 which applies an internal strain to the piezoelectric elements to generate a high voltage therein. The high voltage is

transmitted through the conductors which are respectively associated with the opposite electrodes to generate sparks across in the spark discharge gap between the electrodes. The sparks explosively ignite the gas which has been previously mixed with the primary air flowing into the cylindrical section 151 via the air intake bores 146 as the gas enters the cylindrical section. The ignited gas and air mixture then surrounds and ignites the gas flowing out of the flame spouting nozzle 145. The operation means 58 is further moved in the arrow *x* direction until the centre arched portion of the first valve opening and closing member 60 has passed the associated nozzle 128¹ to allow the nozzle to descend downwardly whereby the first valve 129¹ is closed. This cuts off the flow of the auxiliary gas from the reservoir 130 while leaving the main gas to continue to flow from the reservoir 130 through the valve 129 and gas conduit 149 to the gas nozzle 166 so as to support the combustion of the gas at the nozzle. When it is desired to extinguish the flames, the operation means 58 is moved back in the arrow *y* direction until the first and second valve opening and closing members 60 and 59 again assume the position as shown in Figure 4. In this position the higher lever portion of the second member 59 has passed the nozzle 128 to allow the nozzle to descend and close the associated valve, and the centre arched portion of the first valve opening and closing member 60 has also passed the associated nozzle 129¹ to allow that nozzle to descend and close the associated valve whereby the flow of the gas from the reservoir is cut off and the cam 115 again engages with the impact delivery member 62 so that the various parts of the ignition device are ready for a next cycle of operation.

Figure 5 shows a further modified form of burner which is substantially identical with that of Figure 4 except that the single cylindrical section 151 of Figure 4 is replaced by a single cylindrical section 251 formed of a suitable electrically insulative material and that the main gas conduit 249 formed of an electrically conductive material concurrently serving as the negative electrode adapted to be connected to the negative side of the piezoelectric element unit thereby to eliminate the electrode 139 of Figure 4.

Figure 6 shows a further modified form of burner which can resist the heat generated when the gas is burned. In the embodiment of Figure 6, the burner comprises a single cylindrical section 351 formed of a suitable heat-resistance material such as steatite and the section receives an electrically insulative electrode mounting member 340 in its openings formed in the wall there-

of which mounting member is formed of a suitable water-repelling material such as resin. The electrodes 339 and 341 are received in the water-repelling mounting member 340 in the same opposite relation in the section 351 as mentioned in the preceding embodiments. The electrodes 339 and 341 are electrically connected to the opposite polarity sides of the piezoelectric element unit (not shown). The embodiment of Figure 6 is especially adapted to prevent moistening substances from adhering to the areas at and adjacent to the portions of the wall of the cylindrical section where the electrodes are mounted. The construction and arrangements of the remaining parts of the burner of Figure 6 are substantially the same as those of the corresponding parts of the preceding embodiments. Figure 7 is a cross-section of Figure 6 taken along the line A—A of the latter.

Figure 8 is a cross section of a modified version of the electrode mounting member as shown in Figures 6 and 7. The electrode mounting member 440 comprises two semi-circular one half sectors that is to say, a water-repelling sector 451 and a heat-resistance sector 451¹ which receive respectively the opposite electrodes 439 and 441 substantially in the same relationship as in the preceding embodiments.

Figure 9 is a cross section view of a further modified version of the electrode mounting member as shown in Figures 6 and 7 and in the embodiment of Figure 9. The electrode mounting member 540 comprises four sectors, that is, two water-repelling sectors 551 and 551¹ and two heat-resistance sectors 551¹ and 551¹ which are alternately disposed in a circle. With the construction of the electrode mounting member of Figure 9, the distance between the opposite electrodes 539 and 541 is made shorter than that between the opposite water-repelling sectors 551 and 551 whereby the two electrodes can be satisfactorily maintained in an insulative and non-conductive relationship even if the lighter in which the electrode mounting member of Figure 9 is incorporated is operated under high moisture conditions. When the gas lighter as shown in Figures 1 and 2 employs any one of the electrode mounting members as shown in Figures 3 to 9 inclusively, the gas from the gas conduit 49 or 149 first passes through the gas intake opening in the bottom member of the burner into the lower portion of the cylindrical section or sections of the burner and the gas rises upwardly within the burner section or sections at a high velocity while being mixed with the primary air flowing into the burner section or sections via the primary air intake bores in the wall of at least one of the sections. The gas-air mixture then continues to rise up to im-

pinge against the wire mesh 51a whereby turbulent flow is generated in the mixture and the gas and air can be further mixed together to a higher degree. The highly mixed fluid flows up to the discharge electrodes 39 and 41 in the upper portion of the burner section or sections whereupon the electrodes which have been applied high voltages thereupon strike out sparks across therebetween so as to ignite the gas and air mixture in an explosive manner. The thus ignited fluid mixture is discharged from the flame spouting nozzle as flames. Therefore, when the electrodes are held in position in the wall of the burner which includes a heat-resistance area or areas formed of heat-resistance material, such as porcelain and a water-repelling area or areas formed of water-repelling insulative material, such as resin, with a portion of the electrode protruding into the gas passage within the burner section or sections and with at least a portion of the water-repelling area or areas positioned between the electrodes, even when the lighter is operated under high moisture conditions the areas of the burner wall where the electrodes are supported can be prevented from being contacted by moistening substances. Thus, the intermediate areas between the electrode mounting areas in the burner wall can be at all the times maintained in an electrically insulative state and the high voltages applied on the electrodes can positively strike out discharge sparks thereby to assure positive ignition of the gas flowing through the burner. Since the areas other than the water-repelling areas and especially, the areas adjacent to the flame spouting nozzle are formed of heat-resistance material, the possibility of melting away, deformation and/or burning of the non-water-repelling areas by the flames can be minimized thereby to provide a durable and reliable burner device.

Figure 10 shows the intermediate discharge gap arrangement shown in Figure 2 on an enlarged scale. As illustrated the conductor 37 having the lower end connected to the terminal plate 18 (Fig. 2) and the other conductor 37¹ having the upper end connected to one of the electrodes are disposed in an opposed spaced relationship so as to provide a spark discharge gap therebetween. The opposite ends of the conductors 37 and 37¹ have part-spherical electrodes 37a and 37b secured thereto and the gap is shielded from the atmosphere by an insulating cover 38 whereby corona discharge loss in the high temperature atmosphere is prevented. The spherical configuration of the electrodes 37a and 37b is selected to ensure that the electric field across the gap is maintained uniformly and corona discharge loss be decreased. The spherical electrodes 37a and 37b are re-

received in the opposite ends of the conductors 37 and 37¹ and held in position by adhesive.

Figure 11 shows schematically the circuit leading to the piezoelectric elements of the above-mentioned various embodiments. For simplicity of the illustration and description, the circuit is shown as being employed in connection with the embodiment of Figures 1 and 2.

As clear from the foregoing description, when the thumb piece assembly 24 is pushed inwardly toward the opposite inner wall of the main body 1, the valve manipulation roller 22 at the upper end of the lever 21 which rides on the notch 25¹¹ of the inner block 25¹ is also pushed inwardly and accordingly, the lever is rocked in the clockwise direction. The rotational movement of the lever 21 in the clockwise direction causes the roller 23 at the lower end thereof to pivot the valve opening and closing member 27 in the counter-clockwise direction. The pivotal movement of the member 27 in the counter-clockwise direction causes its lower end to lift up the nozzle 28 against the force of the spring within the reservoir whereupon the gas is allowed to flow from the reservoir 30 through the valve and nozzle 28. The gas then flows upwardly through the gas conduit 49 into the gas and air mixing tube 43 where the gas is mixed with the primary air flowing into the tube 43 via the primary air intake bores 46. Simultaneously the rocking movement of the lever 21 in the clockwise direction also causes the eccentric cam 15, which is firmly secured to the lever, to rotate in the clockwise direction so that the cam 15 squeezes the piezoelectric elements 17 together and a high voltage is generated in the piezoelectric element unit. The positive polarity of the voltage is conducted from the terminal plate 18 through the conductor 37, spherical electrodes 37^a and 37^b and conductor 37¹ to the electrode 39, and the negative polarity voltage is conducted from the outer ends of the elements through the chassis 12 and conductor 42 to the electrode 41 whereupon sparks are generated across the spark discharge gap between the opposite electrodes. The sparks ignite the gas-air mixture passing upwardly through the gap and the ignited gas and air mixture force out flames which are discharged from the flame spouting nozzle 45.

Thus, according to the present invention, in the type of fuel ignition device adapted to ignite the flowing fuel by a high voltage spark discharge which takes place as the piezoelectric elements are applied a pressure thereon or the applied pressure is released therefrom, the ignition electrodes are electrically connected to the piezoelectric elements in a high voltage circuit and an intermediate gap provided by the spherical electrodes are

provided in series with the ignition electrodes in the circuit. It should be understood that when a pressure is applied on the piezoelectric elements a high voltage is generated and sparks are struck out across the spark discharge gap between the electrodes supported in the electrode mounting member to ignite the gas and air mixture. When the pressure is released from the piezoelectric elements a lower voltage is generated which is insufficient to ignite the gas-air mixture, but is sufficient to strike sparks across the intermediate spark discharge gap as the piezoelectric elements gradually return to their normal or non-pressurized state. The intermediate gap is shielded from the atmosphere by the insulating cover and accordingly, the electric field across the intermediate gap can be maintained substantially uniform and has a stabilized dielectric breakdown voltage with substantial reduction of loss of electric charge due to corona discharge thereby to assure a high discharge energy. In addition, since the intermediate gap is air-tightly shielded from the atmosphere by the insulating cover, even when the ignition device is operated under a high moisture atmosphere the loss of electric charge due to corona discharge can be substantially reduced and accordingly, the ignition device can positively ignite various types of fuel.

WHAT WE CLAIM IS:—

1. A smoker's lighter comprising a casing, a reservoir for liquified gas fuel, a valve controlling the flow of gas from the reservoir, a burner assembly including a gas passage which terminates in an outlet port, said burner assembly being located in the casing so that the outlet port is substantially coaxial with an opening in the casing, a pair of electrodes each having a portion extending into the gas passage upstream of the outlet port, a piezo-electric generating device adapted to generate a spark between the electrodes, and a member which, when operated, causes deformation of piezo-electric elements in the device and, at substantially the same time, causes the gas valve to open.
2. A lighter as claimed in claim 1 in which a primary air inlet is located in the gas passage upstream of the electrodes.
3. A lighter as claimed in claim 2 in which a porous member extends across the gas passage at a position between the air intake and the electrodes.
4. A lighter as claimed in any of the preceding claims in which the wall of the portion of the gas passage including the electrodes and downstream therefrom is comprised of sections of heat resistant and water repelling material, any path between the electrodes around the wall of the gas passage

joined in the opposite ends of the conductors 37 and 37¹ and held in position by adhesive.

Figure 11 shows schematically the circuit leading to the piezoelectric elements of the above-mentioned various embodiments. For simplicity of the illustration and description, the circuit is shown as being employed in connection with the embodiment of Figures 1 and 2.

As clear from the foregoing description, when the thumb piece assembly 24 is pushed inwardly toward the opposite inner wall of the main body 1, the valve manipulation roller 22 at the upper end of the lever 21 which rides on the notch 25¹¹ of the inner block 25¹ is also pushed inwardly and accordingly, the lever is rocked in the clockwise direction. The rotational movement of the lever 21 in the clockwise direction causes the roller 23 at the lower end thereof to pivot the valve opening and closing member 27 in the counter-clockwise direction. The pivotal movement of the member 27 in the counter-clockwise direction causes its lower end to lift up the nozzle 28 against the force of the spring within the reservoir whereupon the gas is allowed to flow from the reservoir 30 through the valve and nozzle 28. The gas then flows upwardly through the gas conduit 49 into the gas and air mixing tube 43 where the gas is mixed with the primary air flowing into the tube 43 via the primary air intake bores 46. Simultaneously the rocking movement of the lever 21 in the clockwise direction also causes the eccentric cam 15, which is firmly secured to the lever, to rotate in the clockwise direction so that the cam 15 squeezes the piezoelectric elements 17 together and a high voltage is generated in the piezoelectric element unit. The positive polarity of the voltage is conducted from the terminal plate 18 through the conductor 37, spherical electrodes 37a and 37b and conductor 37¹ to the electrode 39, and the negative polarity voltage is conducted from the outer ends of the elements through the chassis 12 and conductor 42 to the electrode 41 whereupon sparks are generated across the spark discharge gap between the opposite electrodes. The sparks ignite the gas-air mixture passing upwardly through the gap and the ignited gas and air mixture force out flames which are discharged from the flame spouting nozzle 45.

Thus, according to the present invention, in the type of fuel ignition device adapted to ignite the flowing fuel by a high voltage spark discharge which takes place as the piezoelectric elements are applied a pressure thereon or the applied pressure is released therefrom, the ignition electrodes are electrically connected to the piezoelectric elements in a high voltage circuit and an intermediate gap provided by the spherical electrodes are

provided in series with the ignition electrodes in the circuit. It should be understood that when a pressure is applied on the piezoelectric elements a high voltage is generated and sparks are struck out across the spark discharge gap between the electrodes supported in the electrode mounting member to ignite the gas and air mixture. When the pressure is released from the piezoelectric elements a lower voltage is generated which is insufficient to ignite the gas-air mixture, but is sufficient to strike sparks across the intermediate spark discharge gap as the piezoelectric elements gradually return to their normal or non-pressurized state. The intermediate gap is shielded from the atmosphere by the insulating cover and accordingly, the electric field across the intermediate gap can be maintained substantially uniform and has a stabilized dielectric breakdown voltage with substantial reduction of loss of electric charge due to corona discharge thereby to assure a high discharge energy. In addition, since the intermediate gap is air-tightly shielded from the atmosphere by the insulating cover, even when the ignition device is operated under a high moisture atmosphere the loss of electric charge due to corona discharge can be substantially reduced and accordingly, the ignition device can positively ignite various types of fuel.

WHAT WE CLAIM IS:—

1. A smoker's lighter comprising a casing, a reservoir for liquified gas fuel, a valve controlling the flow of gas from the reservoir, a burner assembly including a gas passage which terminates in an outlet port, said burner assembly being located in the casing so that the outlet port is substantially coaxial with an opening in the casing, a pair of electrodes each having a portion extending into the gas passage upstream of the outlet port, a piezo-electric generating device adapted to generate a spark between the electrodes, and a member which, when operated, causes deformation of piezo-electric elements in the device and, at substantially the same time, causes the gas valve to open.

2. A lighter as claimed in claim 1 in which a primary air inlet is located in the gas passage upstream of the electrodes.

3. A lighter as claimed in claim 2 in which a porous member extends across the gas passage at a position between the air intake and the electrodes.

4. A lighter as claimed in any of the preceding claims in which the wall of the portion of the gas passage including the electrodes and downstream therefrom is comprised of sections of heat resistant and water repelling material, any path between the electrodes around the wall of the gas passage



including at least one section of water-repelling material.

5 5. A lighter as claimed in claim 4 in which the heat resistant material comprises porcelain and the water repelling material comprises resin.

6. A lighter as claimed in any of the preceding claims in which an auxiliary gap is connected in series with the main spark gap.

7. A lighter as claimed in claim 6 in which the auxiliary gap is provided by a pair of opposed part-spherical electrodes.

8. A lighter as claimed in any of the preceding claims in which the operating mechanism of the voltage generating device comprises a lever rotatably mounted at an intermediate point on a shaft carrying a cam which bears on one end of a firmly located piezo-electric element unit and a valve operating member is actuated by movement of the operating lever, whereby rotation of the operating lever pressurises the piezo-electric unit generating an electrical potential difference which is applied to the electrodes in the gas passage and at the same time the rotation actuates the valve operating member to open the valve and allow gas into the gas passage.

9. A lighter as claimed in any of the Claims 1 to 7 in which a second valve controls the flow of gas from the reservoir through a conduit which leads into the gas passage downstream of the electrodes and

extends along the gas passage to the outlet. 35

10. A smoker's lighter as claimed in Claim 9 in which the gas conduit in the gas passage replaces one of the electrodes.

11. A lighter as claimed in Claim 9 or 10 in which the operating mechanism for the voltage generating device comprises a slidable operating lever carrying a pivotally mounted cam for stressing a spring loaded member adapted to deliver an impact on a piezo-electric element unit and the operating lever is also provided with means for operating both the first and second valves in such a manner that the first valve may be closed while the second valve is open. 40 45

12. A smoker's lighter substantially as described with reference to Figures 1 and 2 taken in conjunction with any of Figures 3, 6 to 11. 50

13. A smoker's lighter substantially as described with reference to Figures 4 or 5 taken in conjunction with any of Figures 7 to 11. 55

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