June 14, 1966 F. HACH, JR., ETAL 3,255,803

TORCH WITH IGNITER

Filed Aug. 23, 1962 4 Sheets-Sheet 1

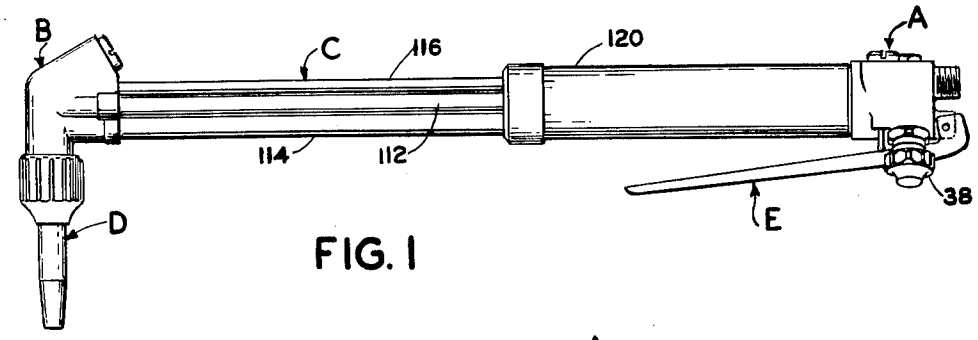


FIG. 1

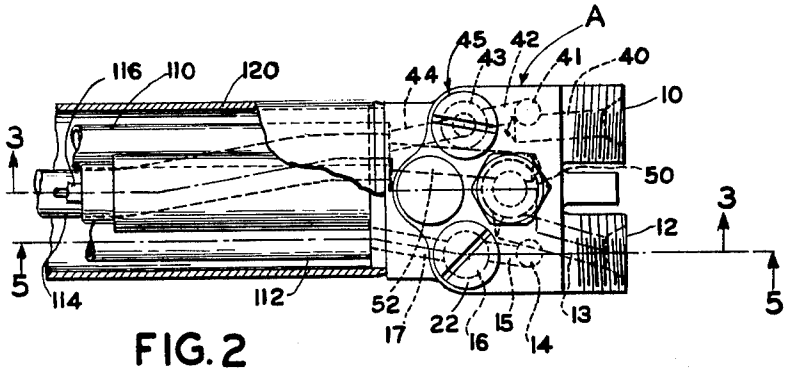


FIG. 2

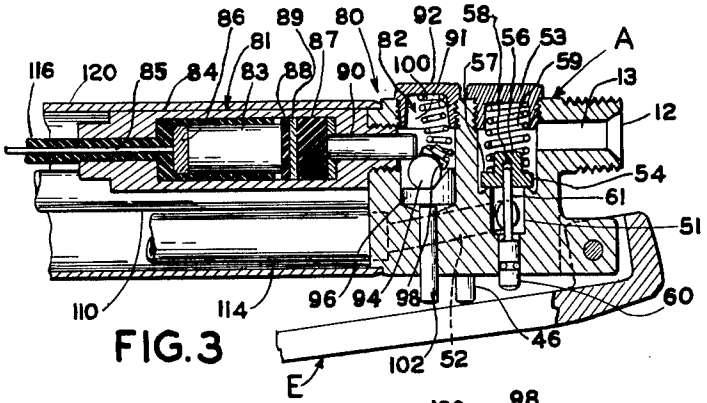


FIG. 3

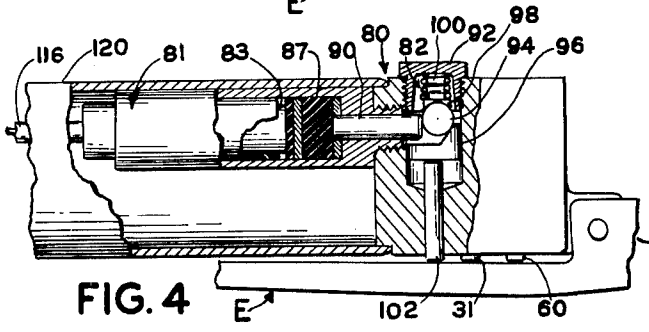


FIG. 4

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TORCH WITH IGNITER

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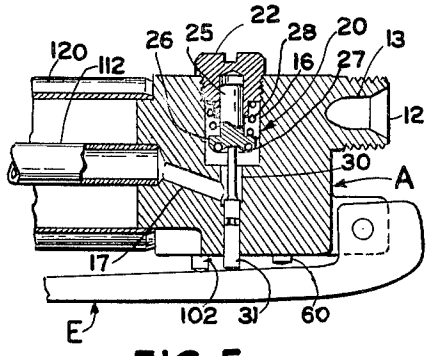


FIG. 5

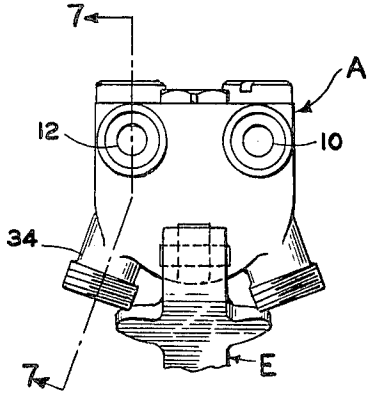


FIG. 6

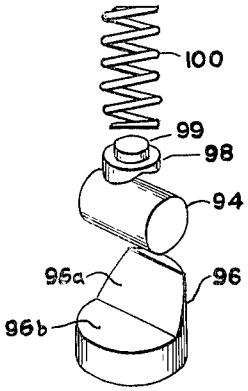


FIG. 11

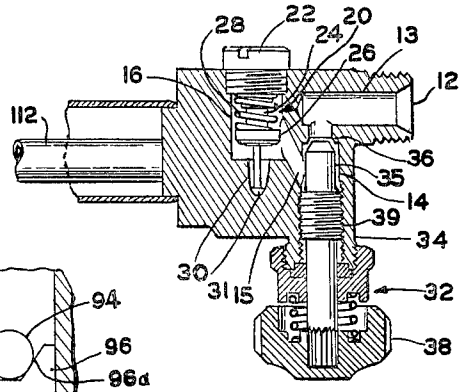


FIG. 7

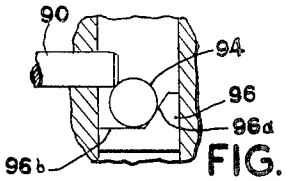


FIG. 12

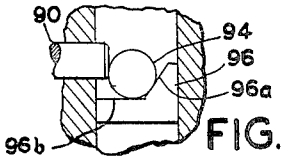


FIG. 13

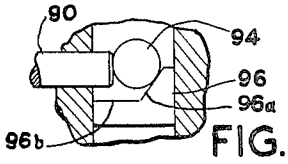


FIG. 14

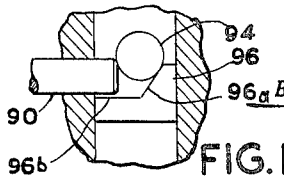


FIG. 15

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TORCH WITH IGNITER

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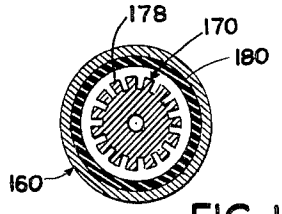


FIG. 10

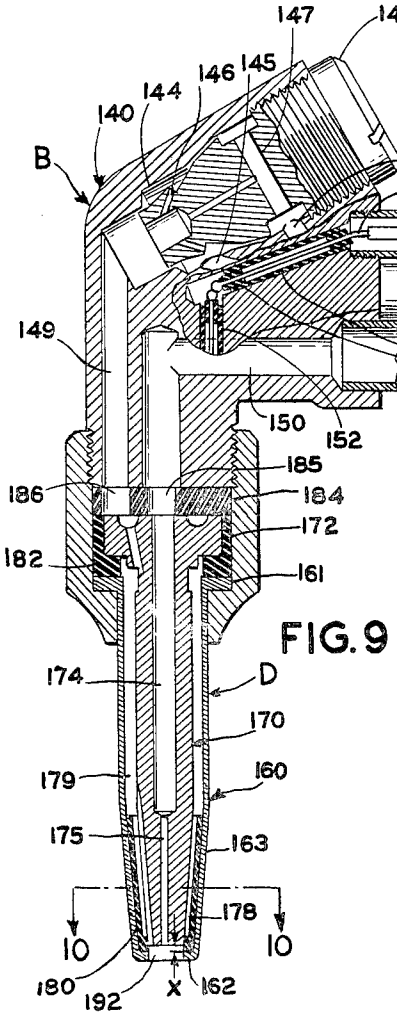


FIG. 9

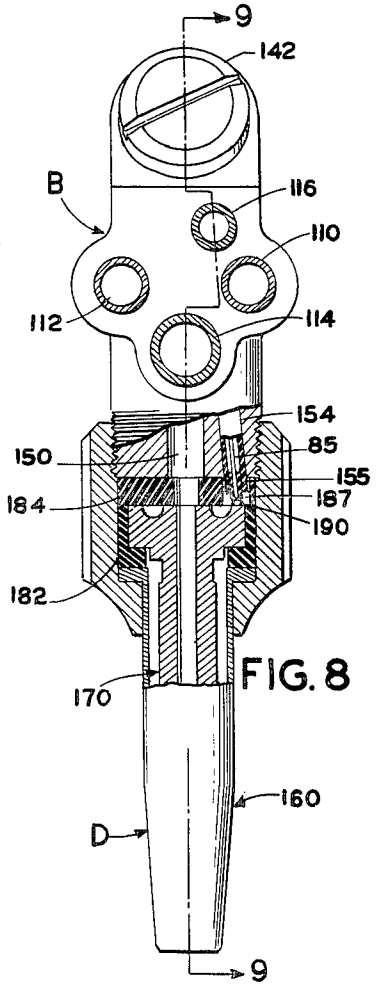


FIG. 8

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TORCH WITH IGNITER

Filed Aug. 23, 1962 4 Sheets-Sheet 4

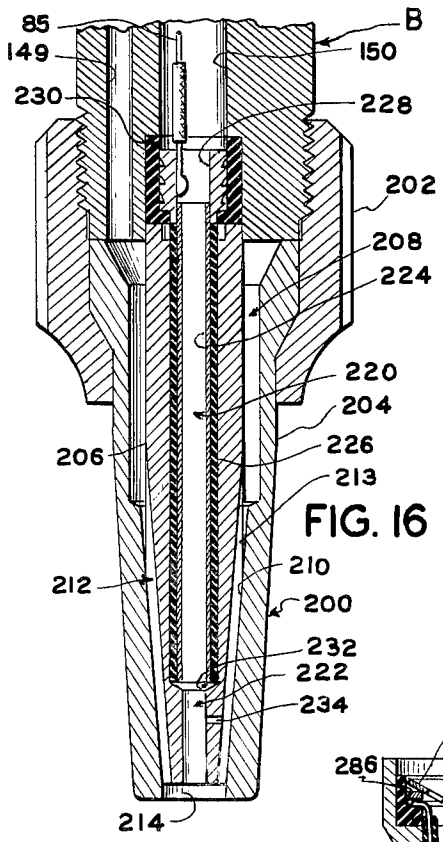


FIG. 16

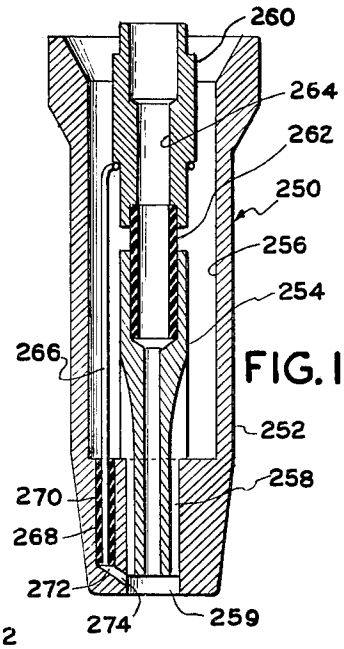


FIG. 17

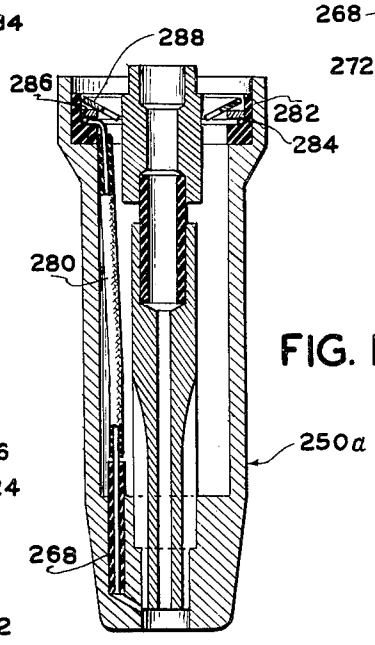


FIG. 18

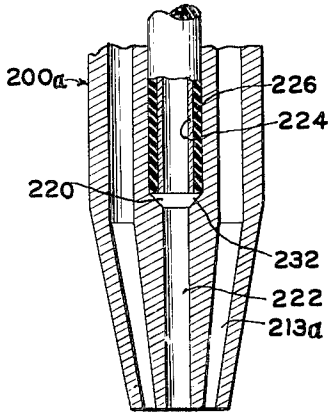


FIG. 19

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United States Patent Office 3,255,803
Patented June 14, 1966

3,255,803

TORCH WITH IGNITER

Frank Hach, Jr., Euclid, and Alfred E. Burnell, Rocky River, Ohio, assignors to The Harris Calorific Company, Cleveland, Ohio, a corporation of Ohio

Filed Aug. 23, 1962, Ser. No. 218,915
8 Claims. (Cl. 158—27.4)

This is a continuation-in-part of application Serial No. 135,940, filed September 5, 1961, now abandoned.

This invention relates to the art of gas burning torches and more particularly to an igniter for a gas burning torch.

The invention is particularly applicable to an oxygen-fuel cutting torch and will be described with particular reference thereto; however, it will be appreciated that the invention has much broader applications and can be used in various gas burning torches, such as those used for welding, soldering, heat treating and brazing.

Oxygen-fuel cutting torches have as their essential components, a supply of a combustible gaseous mixture and a nozzle for directing such mixture toward a workpiece. Various devices are used to ignite this mixture and at the present time the most common of these devices is a manually operated flint sparker which is held near the nozzle and actuated to produce an incandescent particle or spark. This type of igniter has numerous disadvantages; for instance, the spark is created outside the nozzle where atmospheric contaminants tend to dilute the combustible mixture and make it more difficult to ignite. Also, the incandescent particle or spark does not present a substantial concentration of heat so the ratio of gases in the combustible mixture must be controlled within narrow limits to obtain ignition. Consequently, the sparker often has to be actuated several times before ignition of the gases.

Electric spark igniters have also been used with some oxygen-fuel torches; however, because of their high cost, complicated switching mechanisms, large bulk and unreliability, they have not been universally adopted. Also, the spark gap of these igniters was outside of the nozzle; therefore, they presented the same ignition difficulties found in the flint sparker.

Although various electric spark igniters have been used, a spark gap required to produce the electric spark has never been successfully incorporated within a nozzle for a blowpipe which burns a highly combustible mixture such as acetylene and substantially pure oxygen. Such highly combustible mixtures tend to explode and carry the flame back into the interior of the blowpipe which is not only annoying; but is dangerous and tends to cause damage to both the nozzle and the blowpipe. Further, explosions within the nozzle momentarily interrupt the flow of fuel through the blowpipe so that the flame initiated by the spark igniter is very often extinguished for lack of fuel before the supply of fuel can be reestablished. To prevent these explosions within the nozzle of an oxygen-fuel blowpipe or torch, the spark gap was always on the outside of the nozzle so that it was highly susceptible to damage and was often shorted by slag created during the cutting operation.

An igniting spark could be incorporated within a blowpipe nozzle only when air was used to support combustion. Apparently the approximately 80 percent nitrogen and other relatively inert materials of the air tend to prevent a rapid flame propagation and also cause a cooling effect on the flame so that the incidence of explosion within the nozzle is substantially reduced.

Prior gas burning cutting torches were provided with a valving arrangement to control the flow of the combustible mixture of gases which mixture was subsequently

ignited to produce a preheat flame. After the preheat flame heated the workpiece to a temperature that would support combustion, another valve was opened to furnish a supply of oxygen to the heated area of the workpiece. The oxygen would support combustion to thereby cut the workpiece. To decrease the amount of gases used during the operation of the cutting torch, it is desirable to turn off the preheat flame between cutting operations; however, because of the difficulty in igniting the preheat flame, an operator often left the preheat flame burning. This resulted in an increase in the cost of operating the torch because of the waste of the gases and presented a substantial fire hazard as the torch with the preheat flame burning was moved from one workpiece to another.

This invention relates to an igniter for a gas burning torch and an actuator for the igniter that overcomes the disadvantages mentioned above and others, and results in a compact, easily handled torch assembly. Further, the present invention relates to a nozzle for a blowpipe of the type adapted to burn a highly combustible mixture such as acetylene and substantially pure oxygen which is provided with an internal spark gap which will not cause explosions within the nozzle.

In accordance with the present invention, a gas burning torch is provided with an improved igniting device comprised of a piezoelectric crystal, a spark gap adjacent the nozzle of the torch, and a means for causing the crystal to generate a sparking voltage across the spark gap.

Further, in accordance with the present invention, there is provided in a nozzle for directing a stream of a highly combustible mixture from a blowpipe, an outlet for the stream at one end of the nozzle, a passage for increasing the velocity of the stream and having an entrant end remote from the nozzle outlet and an exit end adjacent the nozzle outlet, the improvement comprising: means forming a spark gap inside of the nozzle and means communicating the spark gap to the mixture stream at a point closer to the exit end of the velocity passage than to the entrant end of this passage.

Still further in accordance with the present invention, a gas burning torch is provided comprised of: a valve arrangement to control the flow of the combustible mixture of gases through a nozzle; a spark gap adjacent the nozzle; a piezoelectric crystal capable of generating a voltage to break down the spark gap; and an actuator which opens the valve arrangement and actuates the crystal.

Further in accordance with the present invention, a gas burning torch is provided with a nozzle comprised of an inner member and an outer member which define a fluid outlet passage and a means for producing an electric spark discharge within the passage near the outlet of the nozzle.

The primary object of this invention is to provide an inexpensive, compact, and easily maintained electric spark igniting device for a gas burning torch.

Still another object of this invention is to provide an igniting device for a gas burning torch which ignites the combustible mixture of gases coming from the torch over a wide range of ratios of the gases comprising the mixture.

Another object of the present invention is to provide a spark igniting device for a gas burning torch which requires no external power source and which has no mechanical switch in the electrical circuit.

Still a further object of this invention is to provide an igniting device for a gas burning torch which produces a high concentration of energy at the ignition point.

Another object of this invention is to provide an electric spark igniting device for a gas burning torch which device is completely enclosed within the torch.

Another object of this invention is to provide an electric spark igniting device for a gas burning torch which device causes a spark within an inner chamber of the torch nozzle.

Still another object of the present invention is the provision of a nozzle for a blowpipe adapted to burn a highly combustible mixture which nozzle has an internal spark gap for igniting the mixture.

Yet another object of the present invention is the provision of a spark gap igniter within a nozzle adapted to burn a highly combustible mixture which igniter does not cause explosions within the nozzle.

Another object of the present invention is the provision of a spark gap igniter within a nozzle adapted to burn a highly combustible mixture which igniter is separated from the internal plenum chamber of the nozzle by a velocity passage so that there will be no flame propagation from the igniter into the internal plenum chamber of the nozzle.

Another object of the present invention is the provision of a nozzle as explained above with means for preventing the propagation of flame from the spark gap igniter into the interior of the nozzle.

Yet another object of the present invention is the provision of a spark gap igniter within a nozzle adapted to burn a highly combustible mixture and having a velocity increasing passage extending from the end of the nozzle to an internal plenum chamber within the nozzle which igniter is located near the exit end of the velocity passage and substantially remote from said plenum chamber.

Another object of the present invention is the provision of a spark gap igniter within a nozzle adapted to burn a highly combustible mixture which igniter is so located that it will not become clogged with slag and other waste from the exterior of the nozzle.

Still a further object of the present invention is the provision of a spark gap igniter of the type described above which igniter is located in a separate chamber within the nozzle which chamber is communicated to the interior of the nozzle by a small passage.

Another object of the present invention is to provide an electric spark igniting device having an actuator which first opens the valve controlling the flow of a combustible mixture of gases and then causes an electric spark that ignites the mixture.

A still further object of this invention is to provide a gas burning torch with a piezoelectric igniting device.

Still a further object of this invention is to provide a nozzle for a gas burning torch having an internal spark gap to ignite a combustible mixture passing through the nozzle.

These and other objects and advantages will become apparent from the following description used to illustrate preferred embodiments of the invention as read in connection with the accompanying drawings in which:

FIGURE 1 is a side view of a gas burning torch provided with a preferred embodiment of the present invention;

FIGURE 2 is a partial top view illustrating a preferred embodiment of the present invention;

FIGURE 3 is a cross sectional view along line **3—3** of FIGURE 2;

FIGURE 4 is a partial cross sectional view similar to FIGURE 3;

FIGURE 5 is a cross sectional view along line **5—5** of FIGURE 2;

FIGURE 6 is an end view of the torch;

FIGURE 7 is a cross sectional view along line **7—7** of FIGURE 6;

FIGURE 8 is an end view illustrating a preferred embodiment of the torch nozzle;

FIGURE 9 is a cross sectional view along line **9—9** of FIGURE 8;

FIGURE 10 is a cross sectional view along line **10—10** of FIGURE 9;

FIGURE 11 is an exploded view of a preferred embodiment of the actuating means for the igniting device;

FIGURES 12–15 are progressive views showing the operation of the actuating means illustrated in FIGURE 11;

FIGURES 16–18 are cross sectional views illustrating modifications of the preferred embodiment of the blowpipe nozzle shown in FIGURES 8–10; and

FIGURE 19 is a cross sectional, partial view of a modification of the nozzle shown in FIGURE 16.

Referring now to the drawings, wherein the showings are for the purpose of illustrating a preferred embodiment of the invention and not for limiting same, FIGURE 1 shows a gas burning torch comprised of a valve housing A; a torch head B connected to the valve housing by a plurality of connecting tubes C; a torch nozzle D and an actuator E which in the present embodiment takes the form of a manually operated lever pivotally mounted on the valve housing A. In this embodiment, the gas burning torch is used in cutting metal workpieces and has a preheat cycle wherein actuator E is depressed to cause a combustible mixture to flow from nozzle D which mixture is ignited to form a preheat flame which is used to heat the workpiece to a temperature that will support combustion, and a cutting cycle wherein the actuator E is further depressed to cause an oxidizing fluid to flow from nozzle D to cut the heated workpiece.

In FIGURE 2, the valve housing A is provided with an inlet **10** connected to a source of fuel, such as natural gas, propane, acetylene, etc., hereafter referred to as gas, and an inlet **12** which is connected to a source of oxidizing fluid, such as oxygen, hereafter referred to as oxygen. The flow of both the gas and the oxygen through the valve housing may be accomplished by a number of passage arrengements; however, it has been found that the passages as disclosed in the preferred embodiment are easily machined and require minimum dimensions of the valve housing A. The particular passages as disclosed do not form a part of the present invention; however, they provide for the flow of gas and oxygen through the valve housing in a manner that accommodates the present invention.

Referring particularly to the path of the oxygen through the valve housing A, the inlet **12** communicates with a generally, longitudinally extending passage **13** which is intersected by an intermediate, vertical passage **14** that directs oxygen from the passage **13** to another generally, longitudinally extending passage **15**. Passage **15** directs the oxygen into a valve chamber **16**, from which chamber the oxygen passes through an outlet **17** under the control of a valve **20** which is disclosed in FIGURES 5–7. This valve controls the flow of oxygen during the preheat cycle of the cutting torch. The valve **20** is comprised of a cap **22** threadedly received in the upper portion of chamber **16** to support the valve elements in operating position within the chamber. Reciprocably mounted within chamber **16** is a valve body **24** having an upwardly extending shank **25** reciprocably received within a lower bore of cap **22** and a valve head **26** which has a lower surface for receiving a sealing ring **27**. The valve body **24** is biased downwardly by a compression spring **28** concentrically mounted with respect to shank **25**. The lower portion of the valve chamber **16** is provided with a vertical passage **30** which terminates in a bore that receives a reciprocating plunger **31** extending from the valve housing A and engageable with the actuator E. The plunger is sealed by appropriate means, such as an O-ring. Although valve **20** has been described in detail, a variety of structural modifications may be made without departing from the operation of the valve which in essence forms a normally closed valve between passage **15** and outlet passage **17**.

During the preheat cycle of the torch, the proportion of oxygen and gas which is directed from the valve housing to the torch nozzle must be controlled to assure a com-

bustible and economical mixture at the nozzle; therefore, an adjusting valve is usually interposed in the preheat oxygen path of the valve housing. Of course, the adjusting valve may be located at any position in the preheat oxygen path; however, in the preferred embodiment it is mounted directly onto the valve housing A. (See FIGURE 7.) The adjusting valve **32** is affixed to a threaded boss **34** extending from the valve housing, and is comprised of a needle valve **35** coacting with a conical shoulder **36** within passage **14**, and actuating knob **38** and a shank portion **39** threadedly received within the valve housing so the setting of the needle valve **35** is changed on rotation of knob **38**.

Referring again to FIGURE 2, the gas inlet **10** terminates in a generally, longitudinally extending passage **40** which directs the gas through an intermediate, vertical passage **41** to another longitudinally, extending passage **42**. From the longitudinally extending passage **42** the gas is directed through a valve chamber **43** to an outlet passage **44**. The valve chamber **43** is adapted to house a gas valve **45** identical to the oxygen valve **20** in valve chamber **16**; therefore, detailed disclosure of the gas valve is not necessary. The reciprocating plunger **46** shown in FIGURE 3 operates valve **45** and corresponds to plunger **31** of valve **20**. The intermediate chamber **41** of the gas path through the valve housing is provided with an adjusting valve identical to adjusting valve **32** of the preheat oxygen path. The two adjusting valves are coordinated to provide the proper combustible mixture for the preheat cycle of the torch.

Referring to FIGURES 2 and 3, the longitudinally extending oxygen passage **13**, not only leads to intermediate passage **14**, but also to an additional valve chamber **50** which communicates with a vertical passage **51** to direct oxygen from passage **13** to outlet passage **52**. The valve chamber **50** is closed by a cap **53** and is provided with a reciprocal valve body **54** having a spring guide shank **56**, a valve head **57** and a lower bore **58**. The valve body is biased downwardly by spring **59** to seal chamber **50** from passage **51**. A plunger **60** has an upwardly extending shank **61** slidably received within bore **58** of the valve body **54**. Upward movement of plunger **60** moves valve body **54** to open the valve chamber to provide free flow of oxygen from passage **13** to outlet **52**.

To ignite the combustible mixture of gas and oxygen flowing from the torch nozzle during the preheat cycle, the torch is provided with an igniting device which is comprised of a spark gap adjacent the nozzle, a piezoelectric crystal and a means for causing the crystal to generate a sparking voltage across the spark gap. A variety of structural embodiments of this igniting device could be used, however, in the preferred embodiment disclosed in FIGURES 3 and 4, the igniting device takes the form of a piezoelectric cylinder **81** and a cam firing mechanism **82**. Referring with more particularity to the piezoelectric cylinder **81**, a piezoelectric crystal **83** is threadedly supported on valve housing A by a casing **84** having a forwardly extending conductor, or wire, **85** which leads to the spark gap located within the torch nozzle D. The wire **85** is attached to a contact base **86** which bears against the lower surface of the crystal **83** which is electrically insulated from the casing **84**. To apply uniform pressure onto the upper surface of crystal **83**, the cylinder **81** is provided with a pressure pad **87** which may take various forms; but in the preferred embodiment, is a rubber slug, and the pad bears against an insulation disc **88** and a pressure disc **89**. To exert a compressive stress on the crystal **83** a plunger **90** extends through casing **84** and abuts against pressure pad **87**. Movement of the plunger into the casing causes a multiplied force on the crystal **83** because of the area differential between the upper surface of the crystal and the end surface of the plunger.

The cam firing mechanism **82** as disclosed in the preferred embodiment is comprised of a chamber **91** in the valve housing A into which chamber the end of plunger **90** extends transversely so inward reciprocal movement of the plunger axially stresses the crystal **83**. The chamber **91** is closed by threaded cap **92** and houses the cam arrangement of the firing mechanism **82**. This cam arrangement is comprised of a roller or similar intermediate cam element **94**, a reciprocal cam block **96**, a pressure block **98** having a spring support **99**, a coil spring **100** and a plunger **102** which extends outwardly from the valve housing A (see FIGURE 11). Although the actual shape of the cam block **96** may vary, in the preferred embodiment, the block is provided with an inclined cam surface **96***a* facing generally toward the plunger **90** and a bottom surface **96***b* which supports roller **94** and is adapted to force the roller upwardly as the block is moved upwardly by plunger **102**.

The connecting tubes indicated as portion C of the torch illustrated in FIGURE 1, are used to direct the gas, oxygen and electrical sparking current from the valve housing A to the nozzle head B. Referring to these connecting tubes in more detail, tube **110** is connected to outlet passage **44** and directs gas from the valve housing A to the torch head B; tube **112** is connected to outlet **17** and directs preheat oxygen to the torch head B; tube **114** is connected to outlet passage **52** and directs cutting oxygen to the torch head B and tube **116** extends from head B to carry the wire **85** which directs the sparking current from the crystal **83** to the spark gap located within nozzle D. These tubes serve the ancillary purpose of supporting the torch head B with respect to the valve housing A since in the preferred embodiment they are produced of lengths of tubular metal. To protect the piezoelectric cylinder **81** a portion of the connecting tubes are covered by slidable shield **120** which may be moved toward the torch head B to allow access to the piezoelectric cylinder.

Referring to FIGURES 8–10, the torch head B is comprised of a casing **140** and various passages for the oxygen, gas and electrical wire coming from valve head A. These passages will be described in detail; however, it is appreciated that various structural changes may be made without departing from the spirit and scope of the present invention. The upper portion of the torch head B threadedly receives a mixture plug **142** that mixes the gas and oxygen. The mixture plug is basically comprised of a gas chamber **144** which receives gas from tube **110** through passage **145** and which is provided with a plurality of radially, inwardly extending ports **146** that direct the gas into a stream of oxygen coming from tube **112** through passages **147** and **148**. After the mixture of gas and oxygen leaves the mixture plug **142**, it passes downwardly through passage **149** in the torch head. The torch head is also provided with an angular passage **150** which receives cutting oxygen from tube **114** and directs the oxygen downwardly toward the nozzle D.

The wire **85** which conducts the sparking current caused by the voltage created through stressing the crystal **83**, is directed through tube **116** and passage **152** in the torch head. To insulate the wire **85**, which carries the relatively high voltage, from the casing **140**, the wire is encased within an insulating tube **154** having a number of end caps **155** as shown in FIGURES 8 and 9. These tubes and end caps are formed of various materials, but in the preferred embodiment they are of a ceramic material.

In the preferred embodiment, nozzle D is comprised of an outer sleeve **160** and an inner core **170** which are electrically insulated from each other and are supported on the torch head B. The sleeve **160** is provided with an upper flange **161** and a lower flange **162** and has a conical end **163**. The core **170** is supported within the sleeve **160** and is provided with an upper base **172** having a plurality of obliquely positioned orifices spaced around upper base **172**. By providing a plurality of such orifices leading to annulus **179**, a proper flow of combustible

mixture is provided without substantially increasing the outer diameter of the upper base. A central passage **174** directs cutting oxygen from passage **150** to an outlet bore **175** adjacent the end of the core **170**. To allow flow of the combustible mixture between sleeve **160** and core **170**, the outer surface of the core is provided with a number of grooves **178** near the outlet of the nozzle. The tip of core **170** is illustrated as being conical to match the conical shape of the sleeve; however, the particular configuration of the core and the sleeve is not limited to a conical surface.

The core and sleeve are electrically insulated and at one position they are divided by a short air gap to provide a spark gap. On energization of the crystal **83**, a spark will pass from the core to the sleeve at the spark gap to ignite the combustible mixture of gas and oxygen. This electrical isolation of the core from the sleeve is accomplished by an insulator **180** at the lower portion of the core and the sleeve, a flanged insulator **182** and a disc **184**. To provide for communication of passage **149** and **150** with the appropriate portion of the core **170**, the disc **184** is provided with a central opening **185** and axially offset spaced openings **186**. An opening **187** which in practice may be one of the openings **186** is provided within the disc **184** to allow communication of the wire **85** with base **172** at a point **190** (see FIGURE 8).

Referring to FIGURE 9, a chamber **192** is provided between the lower portions of sleeve **160** and core **170**. By spacing the sleeve from the core at this lower portion, the spark gap is defined by the peripheral edges of the sleeve and core adjacent chamber **192**. The spark gap is within the chamber **192** and the spark will not pass outside of the nozzle. Various modifications in the nozzle and the internal spark gap may be devised without departing from the scope of the present invention. For instance, the lower insulator **180** may be eliminated to allow separation of the lower ends of the core and sleeve by only an air gap which is shorter near the outlet of the nozzle so the electrical discharge occurs at that position. Also, the upper base of the core may be eliminated to form a cylindrical member held against the insulating disc **184** by the insulator **180** near the lower end of sleeve **160**, and the wire **85** may extend through the cutting oxygen passage to contact the upper portion of the core at the oxygen passage. In this manner the cutting oxygen tends to keep the wire **85** dry and clean to prolong its life. Another modification within the scope of the present invention would not require insulation of the core from the sleeve. In this modification, the wire **85** is encased in a flexible refractory material and extends between the noninsulated sleeve and the core to a position adjacent the lower portion of the nozzle. The spark gap is thereby formed between the wire and the sleeve or core. In essence, the nozzle is provided with an internal ignition chamber and a means within the chamber to ignite the combustible mixture flowing through the nozzle.

Refer now to the operation of igniter **80** which is comprised basically of the piezoelectric cylinder **81** and the cam firing mechanism **82** operated by the outwardly extending plunger **102**. Upward movement of the plunger by actuator E stresses the crystal **83** to generate a sparking voltage across the spark gap located within said nozzle. The crystal **83** will generate a voltage when a force is applied to and stresses the crystal, or when an applied force is released from the crystal; and the effective magnitude of the voltage generated by the crystal corresponds to the rate of application or release of the force. Therefore, a voltage is generated by the crystal **83** on inward and outward movement of plunger **90** and the usable magnitude of the voltage will correspond to the speed at which the plunger is operated. In the preferred embodiment of the igniting device disclosed in FIGURES 2 and 3, the plunger **90** is moved inwardly at a relatively low velocity which causes crystal **83** to generate a voltage that is not sufficient to cause a spark within the nozzle and the plunger is, thereafter, moved outwardly at a high velocity to abruptly release the force from the crystal **83** to cause the crystal to generate a sparking voltage which will cause a spark within the nozzle. Since the sparking voltage is generated by the crystal on release of a stressing force there is a time delay between initial actuation of the crystal and the generation of a sparking voltage.

This operation may be accomplished by a variety of structural modifications; however, in the preferred embodiment on initial inward movement of plunger **102** the roller **94** is moved upwardly by cam block **96** to wedge the roller between plunger **90**, bottom surface **96***b* and inclined cam surface **96***a* (see FIGURE 12). Further upward movement of the plunger **102** forces roller **94** upwardly and by a wedging action, the roller **94** exerts an axial force on plunger **90** which moves plunger **90** inwardly against the crystal **83** (see FIGURE 13). The inward movement of the plunger **90** is determined by the speed of movement of plunger **102**; however, the plunger speeds are not directly proportional since the upward displacement of roller **94** causes a substantially lesser inward displacement of plunger **90** which rides over only a small arcuate portion of the external cylindrical surface of roller **94**. With the plunger **90** and roller **94** in the position disclosed in FIGURE 13, force is applied to the crystal **83** by roller **94**. When the reactive force of pressure pad **87** is exerted above the center of roller **94**, as in FIGURES 12 and 13, a downward component of force holds the roller against bottom surface **96***b* and plunger **90** cannot move away from the crystal; however, as the force exerted by pressure pad **87** passes through the center of roller **94** by further upward movement of plunger **102**, the downward component of force is eliminated and the roller is supported by only the cam surface **96***a* (see FIGURE 14). Since the cam surface **96***a* is inclined, the force of the pressure pad **87** abruptly moves the roller along the cam surface to allow rapid outward movement of plunger **90**. This rapid outward movement of the plunger **90** abruptly releases the pressure on crystal **83** to generate a sparking voltage within the crystal which voltage causes a sparking current to pass through wire **85**. Further upward movement of plunger **102** has no effect on plunger **90** since the force transmitting roller **94** is no longer wedged between plunger **90** and cam surface **96***a*. As plunger **102** is released and moved in a downward direction, the cam block **96** is forced downwardly by spring **100** which forces roller **94** back into engagement with bottom surface **96***b* below the inwardly extending end of plunger **90**. During the downward movement of roller **94**, no force is exerted on the plunger **90** since the roller is not wedged between the plunger and surface **96***a*.

The operation of the gas burning torch is accomplished through an actuator means disclosed in the preferred embodiment as a manually actuated handle E pivotally affixed on valve housing A, which handle coacts with plungers **31**, **46**, **60** and **102** to cause flow of a combustible mixture, to ignite that mixture and to cause flow of cutting oxygen in proper sequence. The sequence of actuating the various plungers is determined by the distance the plungers extend from the valve housing and the portion of the actuator which they contact. The actuator E is characterized by having two separate and distinct operating stages which are determined by the angular position of the actuator. During the first stage, the actuator E is pivoted to open oxygen valve **20** and gas valve **45** by inward movement of plungers **31** and **46** to direct a combustible mixture through nozzle D. As the actuator is pivoted to open these valves, plunger **102** is also moved inwardly to apply a stressing force on the crystal **83** which force is released to generate a sparking voltage that ignites the combustible mixture as it passes out the nozzle. An important aspect of this first stage results from the time delay between initial activation of crystal **83** and generation of a sparking voltage which causes a spark in

the nozzle after the valves **20** and **45** have been opened a sufficient time to allow the combustible mixture to pass from the valve housing A to the spark gap in the nozzle. This delay action of the cam firing mechanism has been discussed in detail above wherein it was mentioned that during initial movement of the plunger **102**, a gradual pressure is applied to the crystal and this pressure is thereafter abruptly released on further movement of the plunger **102**. By this construction, the actuator E operates the combustible mixture valve and fires the piezoelectric crystal **83** on a single movement to initiate the preheat cycle of the torch. It is realized that this crystal actuating means may have more and broader applications.

In many installations the gas burning torch will have only the first operating stage, and a separate valve for the cutting oxygen which is required in a cutting torch will not be necessary. However, in the preferred embodiment, the plunger **60** opens a cutting oxygen valve **54** after the preheat cycle has heated the workpiece. The second operating stage of actuator E opens this oxygen valve and is accomplished by further depression of the actuator which moves plungers **31**, **46** and **102** further into the valve housing A and shifts plunger **60** inwardly to open the oxygen valve. Further movement of the plungers **31**, **46** and **102** has no effect on the mechanisms which these plungers control because valves **20** and **45** are fully open during the first operating stage of actuator E and further upward movement of plunger **102** shifts roller **94** further along the plunger **90** without exerting an axial force on that plunger. To illustrate the angular position of actuator E and the position of the various plungers during the two operating stages, FIGURE 3 shows the actuator E prior to the first stage of movement of the actuator; FIGURE 4 shows the position of actuator E after the second stage of movement of the actuator wherein all plungers are depressed.

Referring again now to FIGURES 8–10, during the first stage of movement of actuator E, gas and oxygen is mixed in mixture plug **142** and directed through passage **149** and between sleeve **160** and core **170** to chamber **192**. As the pressure is rapidly released from crystal **83** a potential is created between the core and the sleeve to cause a spark within chamber **192** to ignite the combustible mixture passing between the sleeve and the core. The combustible mixture is ignited before passing into the atmosphere around the nozzle so that the contaminants of the atmosphere do not affect the ionization of the spark path and the ignition of the combustible mixture. When the actuator E is further depressed to the second operating stage, oxygen enters passage **150** and is directed out bore **175** onto the workpiece.

Referring now to FIGURE 16, there is illustrated a nozzle **200** which is a modification of the nozzle D illustrated in FIGURES 8–10. Nozzle **200** is secured onto head B by a tip nut **202** so that the combustible mixture passage **149** and the oxygen passage **150** are communicated to the interior of a nozzle in a manner to facilitate a preheat and cutting cycle for the torch. In essence, nozzle **200** comprises an external sleeve **204** and an internal core or sleeve **206** which when assembled define a plenum chamber **208** appropriately communicated with the combustible mixture passage **149**. Near the lowermost end of the external sleeve **204** there is provided a conical surface **210** that coacts with a conical serrated tip **212** on the internal sleeve **206** to define a plurality of passageways forming a velocity passage **213** having an entrant end adjacent the plenum chamber **208** and an exit end near the outlet of the nozzle. This passage **213** has a substantially reduced cross-sectional area when compared to the area of the plenum chamber so that the velocity of the combustible mixture flowing from the nozzle will be substantially increased to form a well shaped flame adjacent an outlet cavity or combustion chamber **214**. The nozzle **200**, as so far described, receives a combustible mixture from passage **149** which mixture flows into the plenum chamber **208** and out through the velocity passage **213** and chamber **214**.

In accordance with the invention, the interior of nozzle **200** is provided with a spark gap arrangement whereby electrical energy introduced across the gap by the lead **85** is converted into a spark discharge which ignites the mixture flowing through the nozzle. To accomplish this function, the nozzle is provided with a central oxygen passage **220** which is used for directing a stream of oxygen onto a workpiece after the workpiece has been preheated. This oxygen passage terminates in a smaller concentric passage **222** that increases the velocity of the oxygen as it emanates from the nozzle. A conductive coating **224** is provided on a layer of insulation **226** within the oxygen passage **220**; and, the conductive coating **224** may be painted or otherwise coated onto layer **226**, or it may be in the form of a sleeve extending into passage **220** and insulated therefrom by an appropriate insulating means. Adjacent the upper portion of the coating **224** there is provided an electrical connector **228** insulated from the rest of the nozzle by an insulator **230** and connected by an appropriate means onto the lead **85** in passage **150** which, in accordance with the invention, is connected to a source of high voltage such as a piezoelectric crystal **83**. The lower end of coating **224** is spaced only slightly from the internal sleeve **206** to form a spark gap **232**. A bleed passage **234** of small diameter communicates the velocity passage **213** with the outlet passage **222** at a position close to the spark gap **232**. In accordance with the invention, this passage **234** is located closer to the exit end of the passage **213** than to the entrant end of said passage for a reason which will be hereinafter described in detail.

In operation of the nozzle shown in FIGURE 16, the highly combustible mixture within the plenum chamber **208** flows through velocity passage **213** and out chamber **214** and a certain amount of the combustible mixture passes through bleed passage **234** into a position adjacent spark gap **232**. As the high voltage is applied to coating **224** by lead **85**, a spark discharge occurs at the spark gap **232** which causes a flame propagation that either travels through passage **222** to ignite the combustible mixture within chamber **214** or progresses through passage **234** to ignite the mixture as it is travelling through the velocity passage **213**. It is very important that the flame propagation caused by a discharge across spark gap **232** does not progress upwardly into the plenum chamber **208** where an explosion could occur which would interrupt the flow of a combustible mixture and extinguish the flame and/or cause substantial damage to the nozzle. By providing the passage **234** closer to the exit end of the passage **213** than to the entrant end adjacent the plenum chamber, there is a substantial amount of resistance to the flame propagation upwardly into the plenum chamber and very little resistance to the propagation downwardly with the flow of the mixture. Consequently, the velocity passage **213** forms a means for preventing propagation of the flame inwardly into the plenum chamber **208**.

Referring now to FIGURE 17, there is illustrated a modification of the preferred embodiment shown in FIGURE 16. The nozzle **250**, for a blowpipe adapted to burn a highly combustible mixture, has an outer sleeve **252** having a central opening which receives an inner sleeve **254**. These two sleeves define a plenum chamber **256** and a velocity passage **258** which chamber and passage form a combustible mixture passageway. Directly below the velocity passage is an outlet cavity or combustion chamber **259** so that a highly combustible mixture can flow from the plenum chamber through the velocity passage and out the chamber **259**. Directly above the inner sleeve **254** is a nipple **260** which is insulated from the rest of the nozzle and from the inner sleeve by an

insulation tube **262** so that there is provided a continuous oxygen passage **264**.

To ignite the highly combustible mixture flowing out the chamber **259**, there is provided a conductor or conductive element **266** attached to nipple **260** and extending downwardly into a bore **268** where the conductor is supported by an insulator **270** to insulate the conductor **266** from sleeve **252**. By this arrangement, a spark gap **272** is provided between the lower end of the conductor **266** and the inner walls of a small passage **274** so that the spark gap is between the conductor and the outer sleeve. Passage **274** leads from the area adjacent the spark gap to the chamber **259**.

In operation, a spark is created at spark gap **272** and enough combustible mixture is fed into the spark gap by bore or passage **274** that ignition takes place and a flame is propagated through the passage **274** into the stream of high pressure combustible mixture emanating from the velocity passage **258**. This causes ignition of the mixture; and due to the position of the velocity passage **258**, there is no tendency for the ignited gas to travel into the nozzle and cause an explosion. Since the passage **274** is remote from the end of the nozzle, very little slag or other waste material can accumulate at the spark gap **272**. Thus, a nozzle constructed in accordance with the present invention can be operated for a prolonged period of time under extremely adverse conditions without requiring maintenance or replacement.

Referring now to FIGURE 18, there is another modification of the preferred embodiment illustrated in FIGURE 16 which is substantially the same as the embodiment shown in FIGURE 17 with the execption that the conductor extending downwardly into bore **268** is supported onto the nozzle **250***a* by a different arrangement. As is shown, an insulated conductor **280** extends downwardly into the bore **268** and is received at its upper end by an insulated cup **282** at a loop **284** on the conductor. To hold the loop in the cup, there is provided a pressure washer **286** and a lock washer **288**. It is obvious that the operation of the nozzle **250***a* is substantially identical to the operation of the nozzle **250**; therefore, detailed discussion of this operation is not necessary.

The nozzles shown in FIGURES 9, 16, 17 and 18 have been provided with a combustion chamber adjacent the exit end of the nozzle, such as chamber **214** in FIGURE 16. These nozzles are particularly well adapted for use in burning a highly combustible mixture of oxygen and propane. Oxygen and propane have a flame propagation rate which is relatively slow compared with the flame propagation rate of acetylene and oxygen; therefore, without a chamber such as chamber **214** when burning propane, the flame tends to be blown away from the nozzle by the issuing gas. The combustion chamber **214** prevents this by forming a combustion pocket for the propane mixture. When burning a mixture of acetylene and oxygen, the flame propagation is considerably faster; therefore, the chamber **214** is not necessary. Consequently, in accordance with the invention, when acetylene is to be burned, a nozzle such as **200***a* is preferred over a nozzle such as shown in FIGURE 16. The acetylene type of nozzle **200***a* comprises a conductive coating **224** on insulation layer **226**, an outlet passage **222** for oxygen, a spark gap **232** between the conductive coating **224** and the nozzle per se, and a velocity passage **213***a* which is formed from a plurality of drilled holes at the end of the nozzle which end is swaged into a generally conical shape as shown. It is noted, that in the acetylene nozzle **200***a*, the bleed passage **234** is omitted. To obtain ignition in nozzle **200***a*, a spark is discharged across gap **232** and a certain amount of combustible mixture from the stream flowing through passage migrates into passage **222** where it is ignited. The flame propagates through passage **222** and ignites the main stream of the mixture. As in the other embodiments of this invention, the spark gap is communicated to the velocity passage at a point closer to the exit end of the passage than to the entrant end and the spark gap is also within the nozzle.

It is appreciated that a wire passing from the handle of the torch to the nozzle spark gap could be brought to the spark gap through the oxygen tube **114** instead of through a separate tube **116** as is shown in FIGURE 9.

The operation of nozzles **200**, **200***a*, **250** and **250***a* as shown in FIGURES 16, 19, 17 and 18 respectively is not substantially different from the operation of nozzle D with the exception that the spark gap of these nozzles is more protected from extraneous material which may tend to cause fouling. All nozzles disclosed herein comprise an outlet for a stream of highly combustible fluid and a passage for increasing the velocity of the stream as it passes through the nozzle, with the velocity passage having an entrant end remote from the outlet of the nozzle and an exit end adjacent the outlet of the nozzle. In accordance with the invention, the respective nozzles are provided with a means for forming a spark gap within the nozzle and means for communicating the spark gap with the combustible stream at a point closer to the exit end of the velocity passage than to the entrant end of the passage so that the flame propagation initiated by the spark will not tend to go into the nozzle and cause an internal explosion.

The various aspects of the present invention have been described in connection with certain preferred structural embodiments; however, it is to be appreciated that structural changes may be made in these embodiments without departing from the intended spirit and scope of the present invention as defined in the appended claims.

Having thus described the invention, we claim:

1. In a nozzle for directing a stream of a highly combustible mixture from a blow pipe, an outlet for said stream on one end of said nozzle, a plenum chamber in said nozzle, the improvement comprising: first means forming a spark gap within said nozzle and second means for preventing propagation into said chamber of a flame front initiated by a spark across said gap, said first means comprising an inner and an outer conductive sleeve and means for mounting said sleeves with the end of said inner sleeve spaced only slightly from said outer sleeve at a position near the outlet of said nozzle, means for insulating the remainder of said inner sleeve from said outer sleeve, said second means comprising a small cross-sectional area velocity passageway extending from said chamber and having an entrant end and an exit end, and a small bleed passage between said velocity passageway and the end of said sleeve, said bleed passage being closer to the exit end of said velocity passageway than to the entrant end thereof.

2. In a nozzle for directing a stream of a highly combustible mixture from a blow pipe, an outlet for said stream on one end of said nozzle, a plenum chamber in said nozzle, the improvement comprising: first means forming a spark gap within said nozzle and second means for preventing propagation into said chamber of a flame front initiated by a spark across said gap, said first means including an electrical conductor extending through said nozzle to a position adjacent the outlet of said nozzle, means for spacing a portion of said conductor only slightly from said nozzle at a preselected point adjacent the outlet of said nozzle, means insulating the remainder of said conductor from said nozzle, and means communicating said preselected point with the mixture stream flowing through said nozzle, said communicating means including a small bore extending from said preselected point to said mixture stream.

3. The improvement as defined in claim **2** wherein said second means comprises a small cross-sectional area velocity passageway in said nozzle and extending from said chamber and having an entrant end and an exit end, and said small bore extending into said velocity passageway at a point closer to said exit end than to said entrant end.

4. A nozzle for a cutting torch comprising an elongated conductive sleeve with a central opening and an outlet at one end thereof, an elongated cutting oxygen passageway within said opening and communicated with said outlet, a combustible mixture passageway coterminous with said sleeve and said cutting oxygen passageway and surrounding said cutting oxygen passageway, a means for forming a spark gap in said cutting oxygen passageway and adjacent said outlet, and a port communicating said oxygen passageway adjacent said spark gap with said combustible mixture passageway at a point adjacent said outlet.

5. A nozzle for a cutting torch comprising an elongated conductive sleeve with a central opening and an outlet at one end thereof, an elongated cutting oxygen passageway within said opening and communicated with said outlet, a combustible mixture passageway coterminous with said sleeve and cutting oxygen passageway and surrounding said cutting oxygen passageway, a means for forming a spark gap in said cutting oxygen passageway adjacent said outlet, and a port communicating said oxygen passageway adjacent said spark gap with said combustible mixture passageway at a point spaced from said outlet.

6. A nozzle for a cutting torch comprising an elongated, outer conductive sleeve with a central opening and an outlet at one end thereof, an elongated cutting oxygen passageway within said opening of said outer sleeve and communicated with said outlet, a combustible mixture passageway coterminous with said sleeve and said cutting oxygen passageway and also surrounding said oxygen passageway, a conductive element insulated from said sleeve and having an end defining a spark gap with said sleeve, said spark gap being within said nozzle and a port communicating the area adjacent said spark gap with said combustible mixture passageway adjacent said outlet.

7. A nozzle for a cutting torch with an outlet comprising an internal plenum chamber for receiving a mixture of combustible, gaseous material, an annular passageway in said nozzle and communicated with said chamber, said annular passageway being restricted near the outlet of said torch to increase the velocity of said gaseous mixture, a cutting oxygen passageway coterminous with said mixture passageway and centrally mounted with respect to said mixture passageway, means forming a spark gap generally isolated from said chamber and a means for communicating the area adjacent said spark gap forming means with said restricted portion of said mixture passageway, said communicating means comprising a small-area port between said spark gap and said gaseous mixture passageway.

8. In a cutting torch comprising a handle, a nozzle connected onto said handle, said nozzle having an outlet, a passage communicated with said outlet for passing a combustible mixture through said outlet, means forming a spark gap adjacent said outlet for igniting said mixture as it passes through said outlet, a passageway communicated with said outlet for passing substantially pure oxygen through said outlet to perform the cutting operation, a device for generating a sparking voltage across said spark gap, a conductor electrically connecting said voltage generating device across said spark gap and means for actuating said device, the improvement comprising: said electrical conductor being coterminous with and extending through said oxygen passageway in said nozzle.

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