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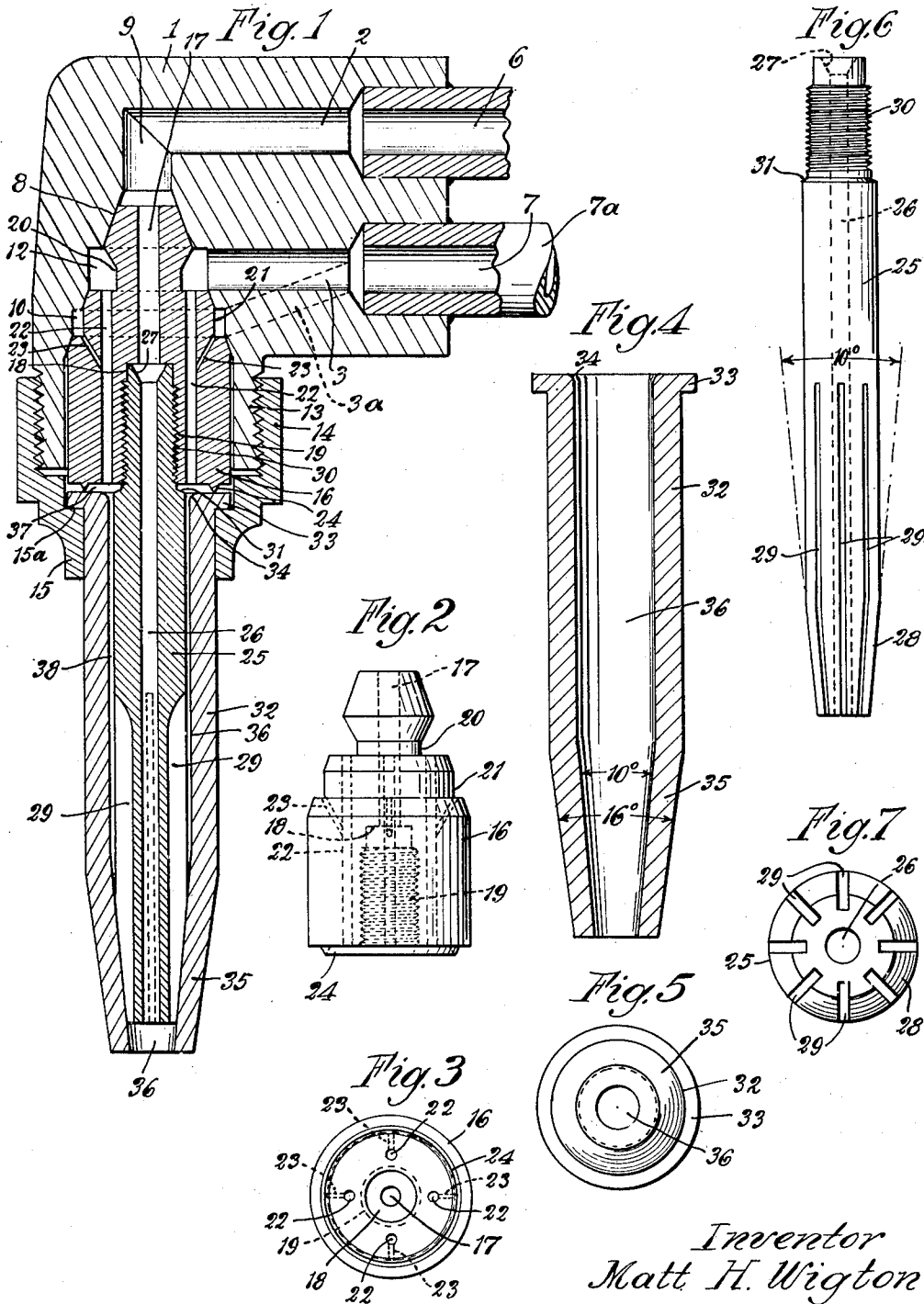
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2,335,330

METHOD OF MIXING AND BURNING FUEL

Filed Oct. 21, 1939

2 Sheets-Sheet 1



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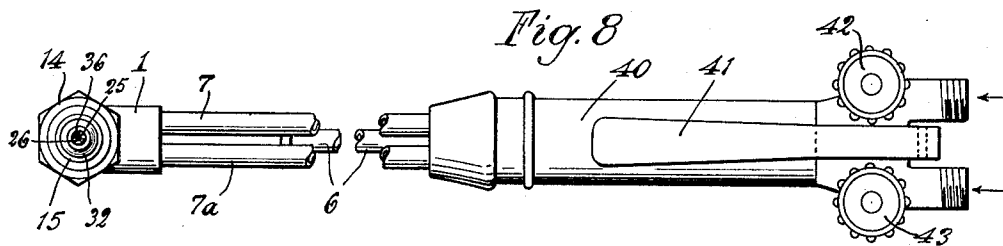
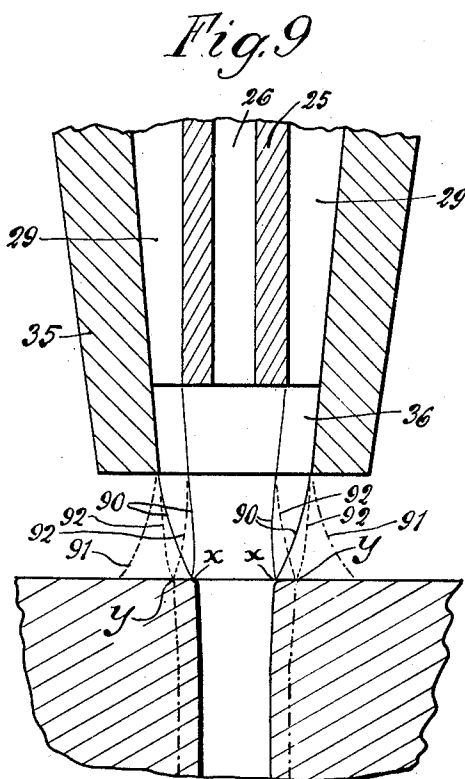
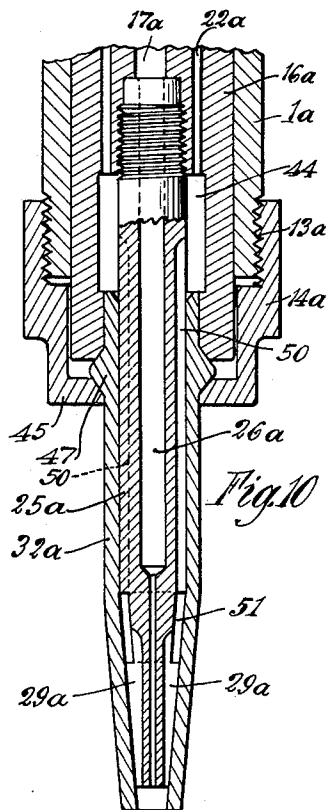
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METHOD OF MIXING AND BURNING FUEL

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2 Sheets-Sheet 2



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METHOD OF MIXING AND BURNING FUEL

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12 Claims. (Cl. 148-9)

This invention relates to a method of and the burning of fuel. In the particular form here shown, it comprises the use of a torch which includes means for receiving and mixing fuel and oxygen or fuel and air, and for conducting a mixture to a point of burning. It involves, also, means for conducting an unmixed supply of oxygen or air to the point of burning. One object of the invention is efficient burning of the so-called "slow burning" gases, namely those gases having a rate of flame propagation slower than acetylene or hydrogen, and generally characterized by not being subject to "flash-backs" into the preheat fuel passages. Typical of these gases is butane. The invention is not limited to the burning of butane. The details of burning and the specific objects of the method of burning will be set out below. The apparatus used in carrying out the present invention, showing two forms of mechanism suitable for carrying out this method, is illustrated in the accompanying drawings wherein:

Figure 1 is a longitudinal section through the burner tip and associated parts;

Figure 2 is an elevational view of the tip base;

Figure 3 is an end view of the base of Figure 2;

Figure 4 is a longitudinal section view of the tip sleeve;

Figure 5 is an end view of the sleeve;

Figure 6 is an elevation of the tip core;

Figure 7 is an end view of the core;

Figure 8 is a bottom view of a welding or cutting tool appropriate for the employment of the tips herein described and shown;

Figure 9 is a diagrammatic illustration of the flame operation of my tip, as contrasted to the application of the prior art tips; and

Figure 10 is an axial longitudinal section through a variant form of my device.

Like parts are designated by like characters throughout the specification and the drawings.

Referring, for example, to Figure 8, I illustrate a tool appropriate for use with my nozzle. It includes, for example, a body portion 40 provided with a pipe or line 6, adapted, for example, to take high pressure oxygen controlled by any suitable valve, which may be controlled by the handle or lever 41, mounted in any suitable fashion on the tool body 40.

I illustrate two additional passage members 7 and 7a, controlled respectively by any suitable valve handles 42 and 43. The line 7 may be employed for directing oxygen, preferably under low pressure, whereas the line 6 may be employed to deliver oxygen at higher pressure. The

line 7a may be employed to deliver an appropriate fuel, such, for example, as butane. All three passages extend to a head portion provided with an inlet 2 for the passage 6, and inlets 3 and 3a for the passages 7 and 7a, respectively.

As shown, the head 1 has a generally tapered enlarged cavity 8 formed in it. The passage 9, which is a continuation of the passage 2, enters the cavity 8 at its apex. The cavity 8 has an annular enlargement 10 which is in communication with the passage 3a, which delivers fuel thereto. An annular enlargement 12 is formed in the cavity 8 and the passage 3 communicates with this enlargement 12, and may deliver low pressure oxygen thereto. The head may have an exteriorly threaded extension 13 within which a part of the cavity 8 is formed and which receives in threaded engagement a tip retainer 14, which includes a portion 15, preferably provided on its interior with a retaining shoulder 15a.

The tip comprises a base 16 which corresponds in shape generally to the cavity 8. A longitudinal passage 17 is formed in the tip. This passage is enlarged adjacent its down-stream end to form a shoulder 18. It may, also, be interiorly threaded as at 19 to receive the tip core as will be described below. The base 16 is grooved or cut away as at 20 to provide what is in effect a continuation or extension of the enlargement 12 of the cavity 8. The tip is also cut away or grooved as at 21 to provide what is in effect an extension or continuation of the enlargement 10 of the cavity 8. Thus, when the base is in place, one annular passage is formed about its exterior by the grooves 12 and 20, and a second annular passage is formed by the grooves 10 and 21, these passages being in communication, respectively, with the passages or ducts 3 and 3a.

Running through the base are one or more longitudinal passages 22 which communicate with the cut away portion 20 and extend to the outer or down-stream end of the base. For each passage 22 there is formed a passage 23 which extends from the space 21 at an incline and enters the passage 22. Thus, fluid in the spaces 10 and 21 flows into the passages 22. The outer or down-stream end of the base may be provided with a raised land 24.

Associated with the tip base is a tip core formed generally of a body portion 25 which is provided with a central bore or passage 26, the upper or up-stream end of which may be enlarged as at 27 if desired. The outside of the core is tapered or inclined as at 28 and a plurality of preferably symmetrically arranged slots

or grooves 29 are formed in the exterior of the core. As shown, particularly in Figure 7, these slots or grooves are preferably arranged radially or generally radially with respect to the center of the core and their depth is relatively greater than their width. This is true even at the outer or down-stream end of the tip. They may advantageously be of generally rectangular cross section and of generally constant width. It will be understood, however, that these slots may be varied in shape and cross section. It is important, however, that the slots be of sufficient depth in relation to their width to provide a substantial space at the inner end of each slot, for a purpose which will later be brought out in detail.

As its inner or up-stream end, the core may be reduced and threaded as at 30 to be received in the correspondingly threaded portion 19 of the base. Adjacent the threading or the reduced portion, the core is provided with an angularly disposed shoulder 31. This angle in the particular form shown is of approximately 15 degrees with respect to a line drawn at right angles to the central longitudinal axis of the core.

Associated, also, with the core and base and surrounding the core is a core sleeve comprising a generally hollow body 32 which may be shouldered at its up-stream end as at 33. The upper edge of the central bore is preferably rounded as at 34. The sleeve is tapered as at 35. Internally the size and shape of the taper correspond generally to the external size and shape of the tapered portion 28 of the core 25. As shown, the angle of inclination of the sleeve with respect to its central longitudinal axis is 10 degrees, and the corresponding angle of inclination of the exterior of the tapered portion of the sleeve is 16 degrees. The taper, of course, reduces the diameter of the internal bore or space 36 formed within the sleeve.

The parts are assembled generally as shown, the core being screwed or otherwise placed in engagement with the base; the sleeve is positioned about the core and the parts are then held in place by the retainer 14 and the shoulder 15a. The raised land 24 assists in preventing leakage and otherwise in spacing the parts.

High pressure oxygen is supplied through the conduit 6. Low pressure oxygen is supplied through the conduit 7, and fuel for mixing therewith through the conduit 7a. The mixed low pressure oxygen and fuel passes downwardly through the apertures 22 to the space 37, thence through the space 38, and finally out through the bore 36 for use. The gas is delivered to the low pressure oxygen passing downwardly through the passage 22 by means of the inclined passages 23. Thus, butane mixed with oxygen is moving downwardly through the passages 22. It emerges from the down-stream end of these passages into the more or less irregular, annular space 37 formed between the lower end of the base 16, the upper end of the sleeve 32, the land 24 and the inclined shoulder 31. The angular relationship of these parts is such that as the mixed gas and oxygen move through the space just mentioned, they are sufficiently disturbed to avoid stratification and, thus, to cause satisfactory and uniform mixing. The spaces are, however, of such size, shape and angular disposition that unsatisfactory eddying does not occur and the normal flow is not impeded and unsatisfactory pressure and flow conditions are avoided.

As the now properly mixed gas and oxygen move downwardly from the space 37 into the an-

nular space 38 between the core 25 and the sleeve 32, they finally enter the grooves or slots 29 and are discharged at the outer or down-stream end of these slots. These mixed jets of gas and oxygen, when they burn, form what are called the "pre-heating flames." Since they begin inside of the outer end of the bore 36, they are to some degree protected and controlled, and since these "pre-heating flames" are relatively deep in a radial direction, they are not materially diluted by the air about them and satisfactory pre-heating burning conditions prevail. This is accomplished in part by the arrangement of the direction and the dimensions of the "pre-heating flames," which are in turn controlled by the shape and depth of the slots 29 and by the positioning of the down-stream end of the core sufficiently within the down-stream end of the sleeve. The proportions of gas and low pressure oxygen are so controlled as to provide a completely oxidized mixture, and when the pre-heating jets burn, they do so without the necessity of the addition of any atmospheric air. The mingling of atmospheric air with the jets is incidental and is not relied upon in producing or supporting the necessary combustion.

In Figure 10 I illustrate a variant form of my device in which a portion of the head is illustrated, as at 1a. Within it is the member 16a, corresponding to the member 16 in Figures 1 and following, although of modified form, shown, for example, as having a generally cylindrical exterior. It is provided with a plurality of passages 22a, through which properly mixed low pressure oxygen and fuel are delivered to the space 44. The member 1a is exteriorly screw-threaded as at 13a to receive the retainer 14a, which has an inwardly extending flange 45 abutting against an enlargement 47 on the sleeve 32a. Within the sleeve is the tip 25a, having a central passage 26a in communication with the high pressure oxygen outlet 17a.

The mixed low pressure oxygen and fuel passes downwardly from the space 44, along a plurality of slots 50. These slots 50 communicate with a space 51, in communication with a plurality of slots 29a, corresponding in size and form to the slots 29 of Figure 7.

Although there is shown an operative form of the device, it will be understood that many changes in the form, shape and arrangement of parts might be made without departing from the spirit of the invention; and it is wished that this showing be taken as, in a sense, diagrammatic.

The use and the operation of this invention are as follows:

The apparatus herewith disclosed, while its use is not limited to the burning of any particular gas, is of special advantage in supplying a more useful source of heat for pre-heating steel or other metal for cutting or wherever rapid heating is desired. It is particularly advantageous in utilizing relatively slow burning gases such as gases which burn with the rate of burning slower than that of hydrogen—that is to say, burning these gases with oxygen as the combustion supporting medium. Such slow burning gases may be differentiated from fast burning gases of which acetylene is typical.

The desired burning of such gases is accomplished by the tip shown herewith which is so designed that the gases can be supplied at a higher speed than is possible with conventional tips and, thus, a greater heat input is applied

at a higher temperature to a highly localized surface. My apparatus and method also produce economies of fuel and oxygen, and permit the cutting of a narrower kerf.

The structure of the present invention operates to carry out the following steps:

1. The fuel and low pressure oxygen are proportionately mixed;
2. They are, then, stirred without unstabilizing turbulence or fluctuation;
3. They, then, pass through an annular passage;
4. They are, then, conducted into suitable passages free of any shoulders, sharp corners or other obstructions, avoiding both turbulence and pulsation;
5. The gases, then, pass to the burner ports, producing a flame, the character of which is determined by the construction shown.

In the particular embodiment shown, the tip is positioned in a head or suitable means for holding the tip and for supplying gas to it. The base 16 preferably provides a part which may be used for all tip sizes—that is to say, it will receive a variety of different tips 25. It comprises means for receiving the core tip and sleeve and means for proportionally mixing the fuel and the gas which supports combustion. The seat upon which the tip is seated comprises a part of the base and is so formed that dirt is prevented from lodging upon it. The gases are mixed by conducting the fuel gas into the oxygen passage through smaller tributary passages at a pressure equal to or preferably greater than the oxygen pressure. In case of restriction of the tip, the fuel gas will prevent the oxygen from backing up into the fuel line and the construction also causes the fuel gas to flow into the oxygen stream in a manner which provides proportional mixing.

After being proportionally mixed, the gases tend to dissolve or to diffuse into each other. This does not take place instantaneously and it is important to provide, as the present mechanism and method do provide, for mixing and dissolving of the gases as completely as possible to avoid uneven combustion. The passages and parts of the apparatus herewith disclosed are so shaped as to hasten the mixing and solution of the gases. They prevent stratification and provide some "stirring" without producing turbulence, pulsation or irregularity which would produce uneven burning. The relationship of the area of the annular passage defined between the tip and the tip sleeve to the area of the passages 29 formed in the tip itself allows the gas to flow into the pre-heat ports—that is to say, the discharge ends of the passages 29—at a low velocity without being affected by shoulders or other obstructions. The burner port itself, as shown particularly in Figure 7, consists of a number of relatively narrow and relatively deep slots arranged generally radially around the center—that is to say, around the outlet end of the oxygen port 26.

This design anticipates adjustment of the flame to a completely balanced mixture of five to six cubic feet of oxygen to one cubic foot of commercial propane, as compared to 4.5 cubic feet of oxygen to one cubic foot of propane, as used in other equipment now produced. Atmospheric oxygen is not relied on. This flame has a higher temperature and a higher rate of flame propagation than one which contains less oxygen and depends on additional oxygen from the at-

mosphere. This is due to the fact that additional oxygen from the atmosphere also carries with it four parts of inert gas, which cools the flame and reduces the rate of flame propagation. My method and apparatus reduce the quantity of additional oxygen from the atmosphere which is burned, and thus, eliminate very largely the taking up of the inert gas which is present in the atmosphere. In considering the slots 29, it is important that they be relatively narrow as compared to their depth and that they extend as close to the center of the tip as is practicable. Actually in Figures 1 and 7, in order to avoid confusion of the lines of the drawings, their inner surfaces are shown as spaced from the passage 26 farther than would be the case in practice. In practice, the inner surfaces of these slots 29 are preferably as close to the walls of the passage 26 as structural and manufacturing conditions will permit.

While I find a generally rectilinear cross section desirable, it will be understood that my primary purpose is to provide a substantially large space at the bottom of each of the slots 29 or 29a for delivering against the metal a jet of completely oxidized mixture, which does not rely at all on atmospheric oxygen. The form of the passages might be considerably varied. Thus a slight inward convergence is practical, or the inner ends of the apertures might be somewhat rounded or arcuate in cross section. The advantage of the sharp corners, however, is that the corners obtain in effect a pilot result, since the gases which flow down the corners flow somewhat more slowly than the gases in the rest of the slot, and therefore provide a more slowly moving stream or streams, effective to maintain ignition and to prevent the flame from being blown from the tip.

In the use of my device, as contrasted for example with prior art tips, Figure 9 illustrates in the light full line, at 90, the shape of my fully oxidized jet. Since it does not depend on atmospheric air, its zone of ignition is at the inner side of the jet, as at x in Figure 9. As the jet leaves the tip, the outer portion of the jet mixes with the atmospheric air and produces a shielding flame of lower temperature, which, however, has some advantage in pre-heating the metal under treatment as the tip is advanced to cross the work. This outer flame is indicated as at 91. It is the ignition zone, however, as at x , which defines the width of the kerf cut and the amount of metal which has to be oxidized in order to cut through the work. In the earlier tips, where the delivery slots 29 are parabolic or circular in cross section, or are arranged with converging walls, the jets rely on atmospheric oxygen for complete combustion, and the form of the actual cutting flame is shown in Figure 9 in dotted line, as at 92, 92, with the zone of ignition on the exterior of the flame. In contacting the metal, as at $y-y$, this results in a wider kerf, and the necessity of oxidizing a greater volume of metal in order to complete the cut.

To summarize, I employ an oxygen-rich mixture, adding to the fuel the full amount of oxygen for complete combustion of the pre-heating jets or flames, as shown in the space bounded by the lines 90. I do this by providing in the slots 29, an inner space, near the passage 26, of substantial cross sectional area, down which the fully oxidized mixture is delivered. The inner portion of the jet is shielded or separated from the out-

side air by a substantial flame wall, as shown at 91.

Where a parabolic or circular or converging wall slot is employed, if there is any area of delivery of a fully oxidized and shielded mixture, which is dubious, it is so much smaller than the corresponding area in the jet in my structure and method, that it cannot have the efficient heating effect necessary to obtain an economical and an efficient result. It becomes necessary, in such tips, to rely on the supply of oxygen from the atmospheric air. For this reason the ignition point, or zone, of the prior art jet is on the outside of the flame, as shown at *y*, whereas my ignition point is on the inner side or edge of each jet, as at *x*. The result is actually a narrower kerf or width of metal to be oxidized.

Furthermore, since in my method and apparatus the portions of the flame which actually contact the metal at the heating point are closer together, they are concentrated on the surface of the steel, the two closely approached heating areas reinforcing each other and decreasing the amount of steel which has to be burned to make the cut. I concentrate the hottest part of the flame on a narrower area than is practical or possible with any prior art tip known to me.

The net results are that less fuel is needed because of the time and temperature relationship, it requiring less fuel to heat a smaller volume of steel, and my jet or tip, involving the heating of a smaller area of the steel to make the cut. Less oxygen is needed, since a smaller amount of oxygen is necessary in order to satisfy the lower volume of fuel employed. Also, less oxygen is required because less steel needs to be oxidized, due to the smaller volume of weight of steel removed in the smaller kerf.

It will be understood, of course, that in the operation of the device, the high pressure oxygen, supplied for burning the metal, is controlled by the lever 41, and the operator, as he moves the tip across the work, is pre-heating the metal by the jets, bounded with the lines 90, and is burning the metal by supplying the high pressure oxygen to the pre-heated area. The low pressure oxygen may be controlled in relation to the fuel by any appropriate setting of the valves 42 and 43.

The purpose of this arrangement is to provide that the gases burning near the center of the flame may be shielded from the atmosphere so that this higher temperature flame may be produced. This effect, combined with the completely mixed non-turbulent flow of the gases which allows a hotter, more concentrated flame which burns more rapidly, thereby reduces the amount of time necessary to bring the surface upon which the flame is impinged to a given temperature.

A principle which is involved in the present invention includes mixing and guiding means in which the proportionately mixed gases are re-directed at a generally obtuse angle for the purpose of "stirring" these gases to break up whatever stratification may have taken place and, thus, to cause uniform and satisfactory mixing throughout.

I claim:

1. The method of mixing and burning fuel which comprises the following steps: Supplying a gas for supporting combustion to a mixing member, supplying a combustible gas thereto, mixing said gases in a ratio capable of supporting substantially complete combustion, conduct-

ing said combustible mixture along a passage and forming said combustible mixture thereafter into a plurality of radially arranged columns of fluid spaced angularly with respect to one another less than 90°, causing said columns to assume shape in which each column has a length in a radial direction greater than its width, and initiating the burning of said combustible mixture.

2. The method of mixing and burning fuel which comprises the following steps: Supplying a gas for supporting combustion to a mixing member, supplying a combustible gas thereto, mixing said gases in a ratio supporting substantially complete combustion, conducting said combustible mixture along a passage and forming said combustible mixture thereafter into a plurality of radially arranged columns of fluid, causing said columns to assume shape in which each column has a length in a radial direction greater than its width, maintaining the inner parts of said columns of combustible mixture shielded by a wall in common from contamination by outer atmosphere and initiating the burning of said combustible mixture.

3. The method of cutting metal which includes mixing oxygen and a fuel in a mixture capable of supporting complete combustion without reliance upon oxygen in the atmosphere, separating the mixture into a plurality of flowing columns, fanning out each column to a rectangular cross section and within an extending wall ejecting the columns around a cutting port with the greater cross-sectional dimension disposed radially with respect to the cutting port and angularly with respect to each other less than 90°.

4. The method of cutting metal which includes mixing oxygen and a slow burning gas in a ratio capable of supporting complete combustion, separating the mixture into a plurality of flowing columns, spreading each column to a cross-sectional contour having one or more sharp corners and ejecting the column at a rate of flow greater than the rate of flame propagation of said slow burning gas, piloting the column at said corner and ejecting a cutting stream of oxygen at the center of said columns, said columns being arranged within a protecting wall and so closely positioned as to minimize entrainment of atmosphere.

5. The method of cutting metal which includes mixed oxygen in a slow burning gas such as butane and propane in a ratio capable of supporting combustion without benefit of atmospheric oxygen, separating the mixture into a plurality of flowing streams, ejecting the main portion of each stream at a rate greater than the rate of flame propagation of the gas, retarding the flow of the stream at one edge to a rate of flow less than said rate of flame propagation, piloting the main stream from the restrained portion, and arranging the streams radially around a cutting port and spaced angularly less than 90°.

6. The method of cutting metal which includes mixing oxygen and slow burning gas such as butane and propane in a mixture for combustion without benefit of atmospheric oxygen, separating the mixture into a plurality of flowing streams flowing at a rate greater than the rate of flame propagation of the gas, restricting the streams to columns of a sectional thinness in one dimension sufficient to accomplish burning of the mixture with a minimum contact with atmosphere to bring the base of the flame close to the work, and ejecting a stream of oxygen onto the work

in sufficiently close proximity to the work that the work is contacted by the stream of oxygen before the stream expands appreciably after ejection.

7. The method of cutting metal which includes supplying oxygen and slow burning gas such as butane and propane to a tip member in a ratio capable of supporting combustion without reliance upon atmospheric oxygen, mixing the gases in said tip and separating the mixture into a plurality of flowing streams, restricting the streams to columns having a rectangular cross-section whose lesser dimension is sufficient to permit burning of the mixture with a minimum contact with atmosphere and ejecting said columns through ports of said rectangular cross section wherein the larger dimension of the cross section is disposed radially around an oxygen cutting port and so positioned compositely as to minimize entrainment of atmosphere.

8. The method of cutting metal with a neutral pre-heat flame comprising mixing oxygen and a fuel in a mixture capable of supporting complete combustion without reliance upon oxygen in the atmosphere, separating the mixture into a plurality of thin flowing columns so closely positioned as to minimize entrainment of atmosphere, projecting the flowing columns through a recessed opening and into a fluid environment and burning the gases before any substantial amount of said fluid environment is entrained to cool the flame and change the working characteristics of the flame.

9. The method of cutting metal comprising mixing oxygen and a slow burning gas such as butane and propane in a mixture capable of supporting substantially complete combustion without reliance upon oxygen in the atmosphere, ejecting the mixture in a stream flowing at a rate greater than the rate of flame propagation of the gas and restricting the stream to a column having a sectional dimension in which the depth is relatively greater than the width and one edge thereof is disposed proximate to a short wall arranged parallel therewith which shields the columns on all sides exposed to atmosphere, said column being disposed edgewise to said wall and having a sharp corner, said width being of a dimension sufficient to permit burning of the mixture with a minimum contact with atmosphere beyond the wall to bring the base of the flame close to the work, retarding the rate of flow of a portion of the column at said sharp edge to a rate of flow less than the rate of flame propagation of the gas, and igniting the faster moving portions of the column from said retarded portion.

10. The method of cutting metal comprising mixing oxygen and a slow burning gas such as butane and propane in a mixture capable of supporting substantially complete combustion without reliance upon oxygen in the atmosphere, separating the mixture into a plurality of streams flowing at a rate greater than the rate of flame propagation of the gas, ejecting the streams in columns restricted to a cross-sectional shape in which the depth is relatively greater than the width with the columns arranged between and substantially edgewise to a cutting stream of oxygen and to a short wall disposed substantially parallel to and bordering the columns, said columns being spaced angularly less than 90° and each sufficient to accomplish burning of the mixture with a minimum contact with atmosphere beyond the wall, retarding the rate of flow of a portion of the columns at said sharp edge to a rate of flow less than the rate of flame propagation of the gas, and igniting the faster moving portions of the column from said retarded portion.

11. The method of cutting metal or the like which includes directing against the surface of the metal one or more pre-heating jets of fuel and oxygen, the proportion of oxygen in said jets being that required for complete combustion of the fuel of each jet, said jets being of sufficient depth in relation to their width to burn the fuel with a minimum entrainment of atmosphere whereby jets of completely oxidized fuel impinge directly against the metal, shielding the burning jets from entrainment of atmosphere over a major portion of their volume, and additionally delivering to the pre-heated area of the metal the oxygen necessary for the combustion of the metal at a point adjacent said jets.

12. The method of cutting metal or the like comprising directing against the surface of the metal a plurality of circumferentially spaced radially disposed pre-heat jets of a fuel and oxygen mixture capable of complete burning without reliance upon entrainment of atmospheric oxygen, said jets being several times deeper radially than they are wide peripherally and so arranged compositely that they are not materially diluted by air about them and burn substantially without cooling effect over a major portion of their volume of inert gases present in the atmosphere whereby jets of completely oxidized fuel impinge directly against the metal, and additionally delivering to the metal within said completely oxidized fuel impingement the oxygen necessary for the combustion of the metal.

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