May 21, 1940. H. E. SERNER 2,201,960

NOZZLE FOR FLAME MACHINING

Original Filed May 7, 1935 2 Sheets-Sheet 1

Fig 1

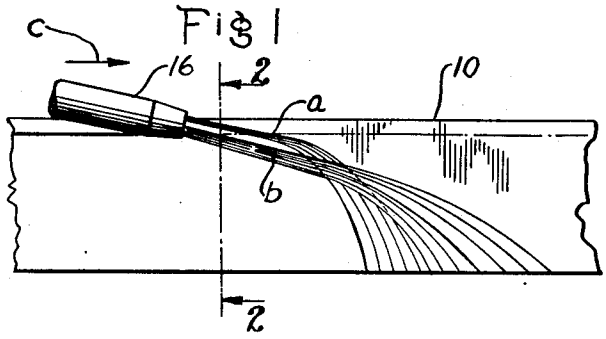


Fig 2

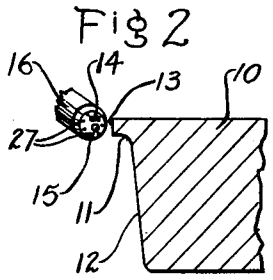


Fig 3

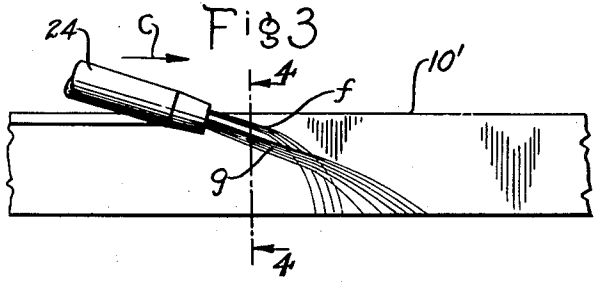
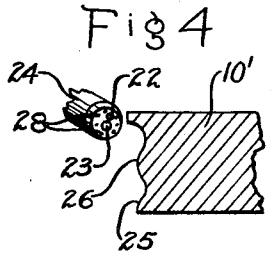


Fig 4



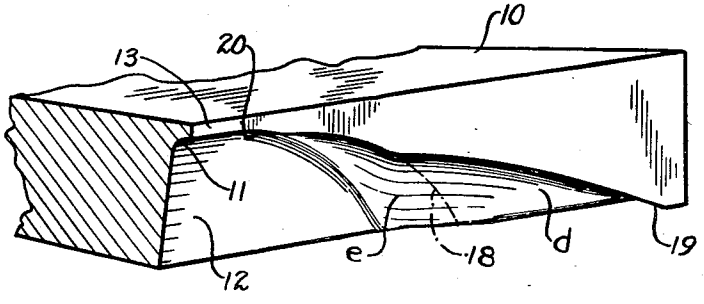


Fig 5

INVENTOR.
HERBERT E. SERNER
BY E. E. Greenewald
ATTORNEY.

May 21, 1940. H. E. SERNER 2,201,960

NOZZLE FOR FLAME MACHINING

Original Filed May 7, 1935 2 Sheets-Sheet 2

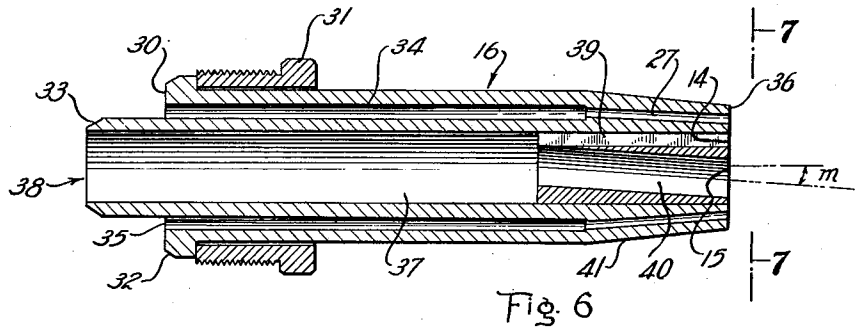


Fig. 6

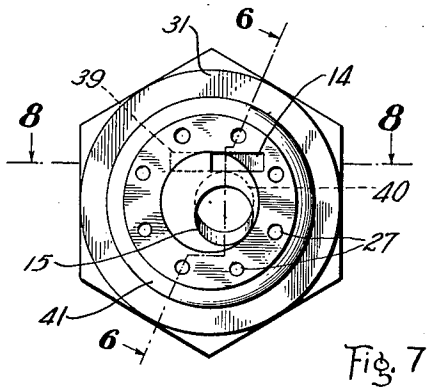


Fig. 7

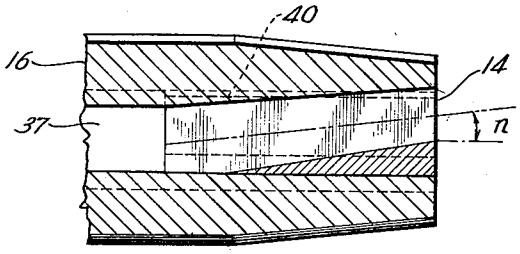


Fig. 8

INVENTOR
HERBERT E. SERNER
BY
E. E. Greenewald
ATTORNEY

Patented May 21, 1940 2,201,960

UNITED STATES PATENT OFFICE

2,201,960

NOZZLE FOR FLAME MACHINING

Herbert E. Serner, Oakland, N. J., assignor, by mesne assignments, to Union Carbide and Carbon Corporation, a corporation of New York

Original application May 7, 1935, Serial No. 20,167. Divided and this application February 19, 1938, Serial No. 191,423

12 Claims. (Cl. 158—27.4)

This invention relates to a nozzle for flame machining wherein heated metal is removed from the surface of a metallic body by progressively applying a plurality of oxidizing gas streams simultaneously to successive portions of such a surface. More particularly, this invention relates to a nozzle to be used with apparatus for flame machining surfaces of metallic bodies to produce shaped surfaces having a predetermined contour.

This application is a division of my copending application Serial No. 20,167, filed May 7, 1935, now Patent 2,125,180, issued July 26, 1938, for an improvement in Method of flame machining.

In starting a flame machining operation to remove metal, a portion of a surface is heated sufficiently to produce a wet surface film of molten metal. When an oxidizing gas stream is applied to such wet film, it tends to spread over an area of surface metal that is subjected to the influence of the oxidizing gas stream. This wet film or puddle, which comprises a mixture of molten metal and oxidized metal, is believed to be essential to enable the oxidizing gas stream to penetrate into the metal to melt and oxidize the same. The heat of reaction resulting from the oxidation of molten metal heats metal ahead of the oxidizing gas stream so that, when the gas stream is progressively applied along the surface, a wet surface film is always produced at the areas acted upon by the gas stream.

Although I do not wish to be held to the exact theory of flame machining just described, constant observation and study of flame machining operations indicate that the wet surface film produced is essential to maintain a cut and remove metal continuously from successive portions of a surface.

In accordance with my invention, surfaces having a predetermined contour are produced by flame machining by controlling the shape of the wet surface film and the manner in which it is formed at successive surface portions from which metal is to be removed. The nozzle according to my invention provides a plurality of oxidizing gas streams which are utilized to control and maintain a single wet surface film or puddle, with one of the streams applied to a surface at the rear of a preceding gas stream to produce the desired cut in a single pass of the gas streams relatively to the metallic surface. By this method surfaces having a predetermined contour can be produced which are exceptionally smooth with no rough portions to define the separate action of the individual oxidizing gas streams.

The objects of this invention, therefore, are: to provide an improved nozzle having two or more discharge orifices for producing a plurality of oxidizing gas streams which, when applied on a metallic surface, effectively coact to produce a relatively smooth cut for effectively removing metal to produce a surface having a predetermined contour; and to provide such a nozzle having two oxidizing gas stream orifices arranged to provide streams which have different cross-sectional shapes, which are directed toward the surface of the work at different angles and which have desired relative velocities so that surface metal may be removed in a manner that produces a predetermined contour on a surface of a metal body.

Further objects and advantages of my invention will become apparent as the following description proceeds, and the features of novelty which characterize my invention will be pointed out in the claims annexed to and forming a part of this specification.

In the drawings, Fig. 1 diagrammatically illustrates one manner of using the nozzle of this invention for applying two oxidizing gas streams at the edge of a metallic body to coact and produce a smooth cut; Fig. 2 is a view taken at line 2—2 of Fig. 1 to illustrate more clearly the contour of the surface produced; Fig. 3 is a view similar to Fig. 1 and diagrammatically illustrates the use of another form of the nozzle for applying two oxidizing streams which coact on the surface to produce a cut having a contour different from that produced in Fig. 1; Fig. 4 is a view taken at line 4—4 of Fig. 3 to show more clearly the type of cut produced; Fig. 5 is a perspective view of the metallic body shown in Fig. 1 to illustrate more clearly the manner in which the metal is removed to produce the cut; Fig. 6 is a sectional view of a nozzle embodying the principles of this invention, taken at line 6—6 of Fig. 7; Fig. 7 is an end view of the nozzle taken at line 7—7 of Fig. 6; and Fig. 8 is a sectional view of the nozzle taken at line 8—8 of Fig. 7.

Since it is believed that metal removal is effected in flame machining through the agency of a wet film, as previously mentioned, practically any predetermined surface contour can be produced by properly applying the oxidizing gas streams to control the shape and size of the wet surface film and the manner in which it is produced at successive portions of the surface. The length of time any given point is subjected to and

under a cutting action or influence is dependent upon the rate of movement of the gas streams and the size and shape of the wet surface film formed and acted upon by the oxidizing gas streams. Further, the amount of metal removed is dependent upon the quantity of oxidizing gas applied to the wet surface film or puddle at successive portions of the surface.

The principles of the present invention have been successfully carried out in practice by progressively applying one or more oxidizing gas streams to heated surface metal and applying an auxiliary oxidizing gas stream to the surface metal at the rear of the first-mentioned gas streams, the rear gas stream being applied in such a manner that it will tend to merge with one or more of the preceding gas streams. Such an auxiliary gas stream may be applied to surface portions to which the preceding gas streams are applied as well as to surface portions adjacent to and adjoining the surfaces to which the preceding streams are applied.

In some instances the desired direction of flow of the auxiliary oxidizing gas stream may be obtained by applying the stream directly in the desired direction; and in other instances the desired direction of flow of such auxiliary stream may be obtained by applying the stream in such a manner that it is deflected on the metallic surface and subsequently acquires the desired direction of flow. When the auxiliary stream effects the final removal of metal it is desirable in many instances that this gas stream have such a direction of flow that it will sweep substantially over the surface of the finished cut. In addition to the proper direction of flow, the velocity of the auxiliary gas stream preferably is sufficient to blow and force the removed metal substantially across and over the surface of the finished cut that is produced.

The type of cut made is dependent upon the direction in which the oxidizing gas streams are applied on a surface. When two oxidizing gas streams are employed, for example, the stream effecting the first removal of metal is applied at the proper angle and direction on the surface. The direction and angle at which the second stream is applied on the surface is then determined to produce a cut which will form the desired finished surface contour. Thus, the manner in which the streams coact or merge can be adjusted to control the shape of the wet surface film and the manner in which it is produced at successive surface portions of the work to produce precisely the cut desired.

In flame machining it has generally been the practice to employ a nozzle having a single circular or an elongated discharge orifice for delivering an oxidizing gas stream. According to the present invention, however, it may be preferable to employ a single nozzle having a plurality of discharge orifices capable of delivering oxidizing gas streams which will coact to produce a smooth cut of a desired contour.

In Figs. 1 and 2 I have diagrammatically illustrated one manner of employing a nozzle, such for example as that illustrated in Figs. 6, 7, and 8, constructed according to the present invention for practicing the above-described method of flame machining to produce a smooth surface having a predetermined contour. The surface contour shown at the edge of plate 10 in Fig. 2 is particularly desirable for electrically welding two of such plates. It will be noted that the portion 11 of the edge surface has a sharp radius of curvature and that the portion 12 extends downward therefrom in substantially a straight line which is at an angle to the original edge or uncut portion 13. When two plates having such an edge surface contour are arranged edge to edge, a U-shaped groove is formed which will permit a welding electrode to extend therein with its fusing end adjacent the very bottom of the groove. This will insure an arc being established between the bottom of the groove and the end of the electrode rather than between the side walls of the groove and the electrode; and when the former occurs a sound and firm weld deposit is obtained.

To make a cut which will produce the surface indicated at 11 and 12 in Fig. 2, a plurality of oxidizing gas streams are employed. As diagrammatically shown, two oxidizing gas streams *a* and *b* may be discharged from the orifices 14 and 15 of a nozzle 16. In this particular application of my invention, the nozzle 16 is positioned at a slight acute angle to the edge 13 and in such a direction that the metal removed is blown ahead of and sideways of the cut as it is being made.

The oxidizing gas stream *b* is so applied that it effects the first removal of metal from the edge of the plate 10. As shown in Fig. 1, the gas stream *b* strikes the surface about a third of the distance from the top surface of the plate 10. Assuming the surface metal to be sufficiently heated to have a wet surface film formed thereon, melting and oxidization immediately takes place, and surface metal in the form of slag is blown ahead of and sideways of the cut, along the surface, by the force of the oxidizing gas stream.

The oxidizing gas stream *a* is applied on the surface of the plate 10 adjacent the uncut portion 13 thereof. The gas stream *a* is arranged to strike the edge at a greater acute angle than the gas stream *b*, so that it will effect the last removal of metal as successive surface portions of metal are removed in the direction indicated by the arrow *c*. Upon striking the edge surface of the plate 10, the gas stream *a* produces the curved portion 11 having a sharp radius of curvature. The gas stream *a* is deflected by the curved portion 11 that it produces, flows under the gas stream *b*, and sweeps across and over the edge surface of the plate 10. In flowing over the lower part of the edge surface of the plate 10, the gas stream *a* tends to merge with the gas stream *b* and cooperates therewith to remove additional surface metal from the lower portions of the edge surface. In order that the portion 12 of the cut will be substantially straight, as shown, the velocity of the gas stream *a* is sufficient to sweep across and over the entire surface of the finished cut that is produced.

The action of the oxidizing gas streams *a* and *b* during a metal removing operation is clearly shown in Fig. 5. As the cut is progressively being made, the gas stream *b* effects the initial removal of metal from a surface portion *d* extending between the dotted line indicated at 18 and the point 19. Directly behind the gas stream *b* the gas stream *a* effects the removal of a surface portion *e* extending between the point 20 and the dotted line 18. Thus the gas stream *a* effects a complete removal of surface metal over the entire edge to provide a cut which is exceptionally smooth with no rough portions to define the separate action of the streams *a* and *b*. A cut having a sectional surface contour as shown in Fig. 2 may be produced when the orifice 14 that discharges the gas stream *a* is rectangular in

shape and the orifice 15 that discharges the gas streams *b* is substantially circular in shape.

As mentioned above, the shape of the surface contour produced can be varied by employing gas streams that are discharged from different shaped orifices of a nozzle or nozzles. In order to produce the cut shown at the edge surface of plate 10' in Fig. 4, for example, two gas streams *f* and *g* may be employed which are discharged from circular orifices 22 and 23 of another form of the nozzle 24. The action of the gas streams *f* and *g* are the same as gas streams *a* and *b*, described above, and hence will not be repeated here. It will be noted, however, that even though the gas streams merge and coact to produce a smooth cut having a double curvature, the velocity of the rear gas stream *f* that effects the final removal of metal is such that the desired projection 25 at the bottom of the cut 26 is produced.

In flame machining it is generally desirable at least initially to preheat surface metal to an elevated temperature so that the wet surface film will readily form as the oxidizing gas streams are moved relatively to the surfaces, and this may be done in any suitable manner. For example, an electric arc may be utilized to preheat the surface metal to an elevated temperature; or the metallic body from which surface metal is to be removed may first be heated to an elevated temperature, as in a furnace. I have found it preferable to preheat successive portions of surface metal to an elevated temperature by high temperature heating flames prior to the application of the oxidizing gas streams. This may be effectively accomplished by providing each nozzle with a plurality of orifices to provide high temperature heating flames. As shown in Figs. 2 and 4, for example, the nozzles 16 and 24 are provided with a plurality of orifices 27 and 28, respectively, for discharging a suitable combustible gas to provide the heating flames.

In the particular application of my invention illustrated in Figs. 1 and 2, the heating flames strike the edge surface of plate 10 at substantially the same point as the oxidizing gas stream *a*. In starting a cut, the heating flames are first applied on the metal surface and, after the metal has been heated sufficiently to form a wet surface film, the oxidizing gas streams *a* and *b* are then applied to the surface. Since the wet surface film is formed at the surface portion to which the gas stream *a* is applied, the wet surface film spreads approximately to the area of surface metal subjected to the influence of such gas stream, and the oxidizing gas effectively penetrates into the surface to cause melting and oxidation of metal. The heat of reaction resulting from the oxidation of the molten metal heats metal directly ahead of the gas stream *a*, and, since this metal is subjected to the influence of the gas stream *b*, the wet surface film formed will tend to spread over the area subjected to the influence of the latter gas stream. Melting and oxidation of surface metal to which the gas stream *b* is applied then takes place, and, after a cut has thus been started, the heat of reaction resulting from the oxidation of surface metal produces a wet surface film directly ahead of the advancing gas stream *b* to enable a cut to be maintained.

The molten and oxidized metal, which is removed by the gas stream *a* and blown ahead, passes over the surface portions to which the gas stream *b* is applied. Similarly, the metal removed and blown ahead by the gas stream *b* passes over surface portions to which the gas stream *b* is subsequently applied. Such molten and oxidized metal also serves to preheat surface metal and is an important factor in producing and maintaining the wet surface film on the metal surface.

The heat of reaction resulting from the gas stream *b* melting and oxidizing surface metal, as well as the preheating produced by the molten and oxidized metal previously passing over such surface metal, increases the temperature of the base metal to a value considerably above normal. Such base metal might, in a sense, be said to be superheated. Since the gas stream *b* leaves the base metal at an extremely high temperature, the gas stream *a* at the rear of gas stream *b* is extremely effective and efficient in penetrating into the base metal further to oxidize surface metal. In the present application the rear gas stream is applied substantially instantly to the heated metal before the heat in the surface metal has an opportunity to be conducted into the plate and away from the surface.

After each cut has been started and is in progress, the supply of combustible gas for the preheating flames may be partially or completely shut off in some instances to effect an economy in gas consumption. This is possible because the oxidized metal or slag, which is driven forward and continuously being heated by its combustion with oxygen, usually has sufficient heat to heat to an elevated temperature the portions of surface metal over which it passes and which are subsequently subjected to the influence of the oxidizing gas streams. In many instances, however, it is desirable to apply heating flames during an entire flame machining operation so as to remove a greater amount of surface metal per cubic foot of oxidizing gas. The removed metal blown ahead of or sideways of the cut, as it is being made, is reduced substantially to a non-adherent granular state.

Although I do not wish to be limited thereto, flame machining according to the above-described method has been successfully carried out in practice when the pressure of the oxidizing gas supplied to the nozzle and the relative cross-sectional areas of the oxidizing gas passages were so proportioned that the velocities of the oxidizing gas streams discharged ranged from 200 to 1,000 feet per second. In most applications, however, the pressure of the oxidizing gas is adjusted to produce oxidizing gas streams having a velocity between 550 and 750 feet per second. The velocities of the oxidizing gas streams just given are the calculated velocities of the gas discharged from the nozzles, based on the assumption that a measured quantity of gas discharged in a given time has a temperature of 70° F. and is at atmospheric pressure.

Referring more particularly to Figs. 6, 7, and 8, the nozzle 16 embodying the principles of this invention may have a shoulder 30 at its inner end. An externally threaded clamping nut 31 disposed about the nozzle and bearing against the shoulder 30 is provided for securing the nozzle to a blowpipe head or adaptor, so that the tapered seating surfaces 32 and 33 will engage and form a gas-tight seal with similar seating surfaces in the blowpipe head, which supplies the oxidizing gas, such as oxygen or a mixture of oxygen and air, and a combustible gas, such as a mixture of oxygen and acetylene, to the nozzle.

Disposed within the outer wall of the nozzle is a group of passages 34 which are substantially equally spaced and which extend longitudinally thereof from an inlet 35 to orifices 27 in the discharge face 36, which discharge face is preferably normal to the longitudinal axis of the nozzle and concentric therewith. The combustible gas is delivered from the blowpipe head and through the passages 34, which passages have their orifice portions 27 reduced in cross-sectional area at the outer or discharge end of the nozzle. An oxidizing gas passage 37, having an inlet 38 communicating with an outlet in the blowpipe head, extends longitudinally through the nozzle and terminates a short distance from the extreme end of the nozzle. From the outer end or outlet of the passage 37 two separate gas passages 39 and 40 extend from passage 37 to orifices 14 and 15, respectively, in the discharge face 36 of the nozzle.

The oxidizing gas passing through the passage 37 is therefore diverted into the passages 39 and 40 to provide two oxidizing gas streams. Where more than two oxidizing gas streams are deemed necessary, the nozzle may be provided with a greater number of passages at the discharge end to provide the number of oxidizing gas streams desired.

The directions in which the oxidizing gas streams are discharged and applied on a metallic surface will depend upon the particular surface contour desired. In the present embodiment, in order to produce the surface contour shown in Fig. 2, the axis of the circular gas passage 40 is inclined at a relatively small angle m to the axis of the passage 37 or the longitudinal axis of the nozzle in a direction away from the rectangular-shaped passage 39, as shown in the vertical sectional view in Fig. 6. The rectangular-shaped passage 39 is also inclined to the concentric passage 37 and to the nozzle axis in a plane transverse to or at right angles to the vertical plane shown in Fig. 6, and its outlet orifice 14 is offset laterally from that of the passage 40, as indicated in Fig. 8. The main axis of the rectangular passage 39 will then make an angle n with the plane of the section shown in Fig. 6. The angle n is shown in Fig. 8 and may be larger than the angle m. The main axes of the passages 39 and 40 lie in different planes and are therefore inclined at a compound angle to each other so that the streams produced thereby will be slightly divergent.

When the nozzle 16 is arranged at an acute angle to the surface of a metallic body from which metal is to be removed, the inclination of the gas passage 39 is toward the surface. With this construction the oxidizing gas stream discharged from the passage 39 and orifice 14 will strike the surface at a point closer to the discharge face 36 of the nozzle than the gas stream discharged from the passage 40 and orifice 15. To permit the gas stream discharged from the rectangular-shaped passage 39 to contact or strike the surface at the shortest possible distance ahead of the nozzle, the passage 39 is so formed that the side walls thereof converge toward the orifice 14, as indicated in Fig. 8. This produces a gas stream which flares sideways immediately after being discharged from the orifice 14, so that it is effectively utilized to produce the portion 11 of cut shown in Fig. 2, which portion preferably should have a sharp radius of curvature to obtain the surface contour desired in this particular instance. In order that the nozzle can be positioned with its tip as close as possible to the surface of a metallic body, the discharge end thereof is tapered, as indicated at 41. This permits the nozzle to be positioned a minimum distance from the metallic body and at the same time insures sufficient clearance as the nozzle is moved relatively to the surface.

In removing metal from an edge surface of a steel plate, it is preferable that the blowpipe head and nozzle 16 be moved at a uniform speed along the edge by mechanical means that maintains the nozzle constantly positioned at the desired angular relation and distance from the edge surface during the movement. Obviously, either the nozzle may be moved along the plate edge or the steel plate edge may be moved relatively to a stationary nozzle or both the nozzle and the edge may be moved so long as the angular relation is maintained and the speed of relative movement is substantially uniform.

In view of the foregoing, it will be apparent that I have provided an improved nozzle for removing metal to produce a surface having a predetermined contour. Although the desired surface contour in most instances can be obtained in a single pass of the oxidizing gas streams, a desired surface contour may also be produced by several passes of the oxidizing gas streams relatively to a metallic body.

The construction of the nozzle 24 may be similar to that of the nozzle shown at 16 but both the orifices 22 and 23 are cylindrical. The orifices 22 and 23 may likewise communicate with a common oxidizing gas supply passage and have their axes inclined to axis of the supply passage in a similar manner.

The nozzle 16 is particularly useful in preparing the edges of relatively thick metal plates for welding. The finished surface, flame machined as described, carries a very thin coating of iron oxides after the loose magnetic oxide has been removed from the surface. The thickness of this iron oxide film is substantially equal to a wave length of light, and beneath such oxide film there is a thin layer of metal containing carbon in an amount greater than that of the original metal before the flame machining operation. In this manner the flame machined surface is so conditioned and improved that subsequent welding of two plates having such surfaces is considerably facilitated, and the resulting welded joint has a strength and uniformity superior to joints heretofore produced in this field of welding.

While I have shown a particular embodiment of a nozzle for carrying out my improved method, it will be apparent that modifications may be made, and certain features can be used independently of others without departing from the spirit and scope of my invention as set forth in the claims.

I claim:

1. A nozzle having at least two oxidizing gas passages for discharging a plurality of independent oxidizing gas streams having different cross-sectional areas, one of said passages having a substantially rectangular outlet.

2. A nozzle provided with at least two oxidizing gas passages having different cross-sectional shapes at the discharge face for discharging a plurality of different shaped oxidizing gas streams, the outlet of one of said passages having a rectangular cross sectional shape.

3. A nozzle having at least two oxidizing gas passages for discharging a plurality of independent oxidizing gas streams; the outlet of one of

said passages being substantially rectangular and the outlet of said other passage being substantially circular.

4. A nozzle provided with a main oxidizing gas passage having an inlet and an outlet spaced from the discharge face of said nozzle, and at least two separate oxidizing gas passages extending from the outlet of said main passage to the discharge face of said nozzle for providing a plurality of oxidizing gas streams, the outlet of one of said separate passages being substantially rectangular and the outlet of the other separate gas passage being substantially circular.

5. A nozzle having a plurality of combustible gas passages extending longitudinally therethrough and terminating in a continuous row of heating gas orifices arranged adjacent the perimeter of the front face of the nozzle; and at least two oxidizing gas passages for discharging a plurality of independent oxidizing gas streams, said oxidizing gas passages terminating in orifices in said face that have unequal cross-sectional areas and are eccentrically disposed within said row of heating gas orifices, the oxidizing gas orifice having the larger cross-section being more centrally located than the smaller of said oxidizing gas orifices.

6. A nozzle having at least two oxidizing gas passages for discharging a plurality of independent oxidizing gas streams, the outlet of one of said passages being substantially rectangular and the outlet of the other passage being substantially circular and the axes of said passages being outwardly inclined with respect to the longitudinal axis of said nozzle.

7. A nozzle having at least two oxidizing gas passages for discharging a plurality of independent oxidizing gas streams, the outlet of one of said passages being substantially rectangular and the outlet of the other passage being substantially circular, the cross-sectional area of the outlet end of said rectangular passage being smaller than the cross-sectional area of its inlet portion.

8. A blowpipe nozzle comprising an elongated body having a front face substantially normal to and concentric with the longitudinal axis of said body and at least two oxidizing gas passages therethrough for discharging a plurality of independent oxidizing gas streams, said passages terminating in orifices in said face, said passages being each inclined at a different angle to said longitudinal axis, and the main axes of at least two of said oxidizing gas passages being in different planes and inclined at a compound angle with respect to each other.

9. A blowpipe nozzle comprising an elongated body having a front face substantially normal to and concentric with the longitudinal axis of said body and at least two oxidizing gas passages therethrough for discharging a plurality of independent oxidizing gas streams, said passages terminating in orifices in said face, said passages being each inclined at a different angle to said longitudinal axis, and the main axes of at least two of said oxidizing gas passages lying in different planes which are offset from said longitudinal axis.

10. A blowpipe nozzle comprising an elongated body having a front face substantially normal to and concentric with the longitudinal axis of said body and at least two oxidizing gas passages therethrough for discharging a plurality of independent oxidizing gas streams, said passages terminating in orifices in said face, said passages being each inclined at a different angle to said longitudinal axis and the main axes of at least two of said oxidizing gas passages lying in planes which are offset from said longitudinal axis and intersect each other substantially perpendicularly.

11. A blowpipe nozzle comprising an elongated body having a front face substantially concentric with the longitudinal axis of said body and at least two oxidizing gas passages therethrough for discharging a plurality of independent oxidizing gas streams, said passages terminating in orifices of different cross-sectional areas in said face, said passages being each inclined at a different angle to said longitudinal axis and the main axes of at least two of said oxidizing gas passages lying in planes which are offset from said longitudinal axis, said main axes being so inclined with respect to each other that the streams produced by said two passages diverge.

12. A nozzle having at least two oxidizing gas passages for discharging independent gas streams, said passages having dissimilar cross sections and different cross-sectional areas, said passages having their axes each offset from the longitudinal axis of said nozzle at different angles in different planes, at least one of said passages being outwardly inclined, said nozzle also being provided with a plurality of passages for combustible gas.

HERBERT E. SERNER.