July 26, 1938. H. E. SERNER 2,125,180

METHOD OF FLAME MACHINING

Filed May 7, 1935

Fig 1

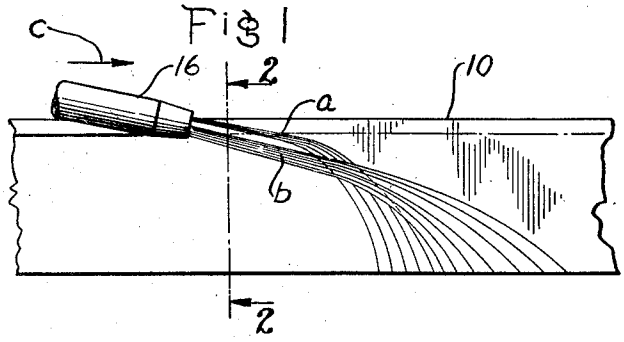


Fig 2

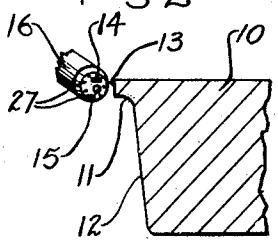


Fig 3

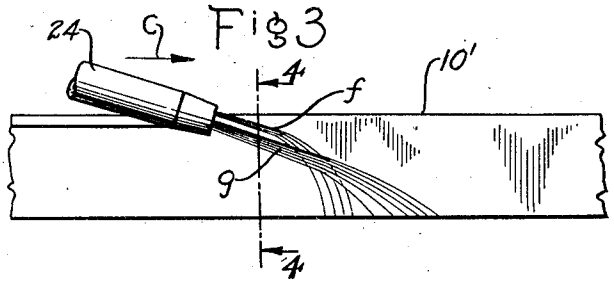
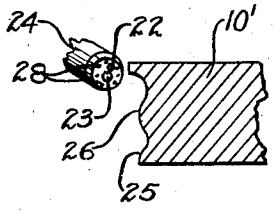


Fig 4



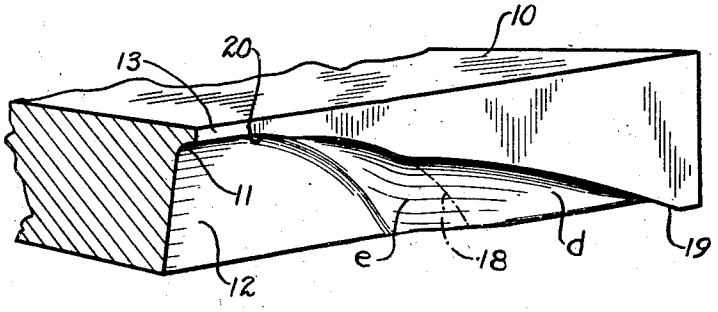


Fig 5

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METHOD OF FLAME MACHINING

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9 Claims. (Cl. 148—9)

This invention relates to an improved method of 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 method of flame machining surfaces of metallic bodies to produce shaped surfaces having a predetermined contour.

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 does 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. In the present application of my invention a plurality of oxidizing gas streams 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 method of flame machining whereby surface metal can be removed in such a manner that any predetermined surface contour can be produced; to provide such a method of flame machining in which a plurality of oxidizing gas streams are applied on the surface of a metallic body and coact to produce a relatively smooth cut.

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 drawing Fig. 1 diagrammatically illustrates one manner of practicing this invention in which two oxidizing gas streams are applied at the edge of a metallic body and coact to 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 action of two oxidizing streams which coact 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; and 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.

Since it is believed that metal removal is effected in flame machining through the agency of a wet film, as previously mentioned, 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, and the present method of flame machining can be effectively carried out by utilizing a plurality of such nozzles. By varying the shape of one or more of the discharge orifices of the nozzles employed, changes in the contour of a cut can readily be produced. In place of several independent nozzles, it may be preferable in some instances 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 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 a 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 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 to further 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 when cooled.

Although I do not wish to be limited thereto, flame machining according to the above described method has been successfully carried out in practice with oxidizing gas velocities ranging from 200 to 1,000 feet per second. In most applications, however, the pressure of the oxidizing gas is adjusted to produce an oxidizing gas stream having a velocity between 550 and 750 feet per second. The velocities of the oxidizing gas stream 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.

In removing metal from an edge surface of a steel plate, it is preferable that the blowpipe head and nozzle 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 may be moved relatively to the nozzle so long as the angular relation is maintained and the speed of relative movement is substantially uniform.

A nozzle and an apparatus which are suitable for carrying out the process are described and claimed in application Serial No. 191,423, filed February 19, 1938, and application Serial No. 192,355, filed February 24, 1938, respectively, which applications are divisions of this application.

In view of the foregoing, it will be apparent that I have provided an improved method of 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, it is within the scope of my invention to produce cuts with several passes of the oxidizing gas streams relatively to a metallic body.

The present method of flame machining 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.

What is claimed is:

1. A method of flame machining in which heated surface metal is removed from a metallic member, which comprises simultaneously and progressively applying at least two oxidizing gas streams obliquely against and along such surface to produce and maintain a wet surface film, said gas streams penetrating into the surface at said wet film to oxidize and melt metal with the heat of reaction resulting from the oxidation of the molten metal heating metal ahead of the gas streams so that a wet surface film is always maintained at the surface portions acted upon by said gas streams, said method further including the step of directing said gas streams at different acute angles toward said surface to control the shape of the wet surface film and the manner in which it is formed at successive surface portions to produce a surface having a predetermined contour.

2. A method of removing heated surface metal to produce a substantially smooth surface having a predetermined contour, which comprises simultaneously and progressively applying at least two oxidizing gas streams obliquely against and along such a surface to produce and maintain a wet surface film at successive surface portions and to remove oxidized and molten metal at such portions, each of said gas streams being applied at a different acute angle toward said surface and having a different component of force in the direction from which metal is removed to affect the shape of said wet surface film and the manner in which it is produced at successive portions of said surface.

3. A method of removing heated surface metal from a body to produce a cut having one edge thereof sloping inward from an uncut portion of said surface, which comprises applying obliquely against and along such surface at least one oxidizing gas stream so as to remove surface metal; relatively moving said stream and said body in a direction parallel to said surface; and, during such relative movement, applying another oxidizing gas stream obliquely against said surface adjacent the uncut portion thereof so as to remove metal to produce the sloping edge; said last-mentioned stream being inclined away from said uncut portion and deflecting over the sloping edge and at least partly contacting successive surface portions at the rear of said other stream and merging therewith to aid said other stream in producing said sloping edge.

4. A method of removing heated surface metal from a body to produce a cut having one edge thereof sloping inward from an uncut portion of such surface, which comprises progressively applying at an acute angle to and along such surface a plurality of oxidizing gas streams each having a component of force in the direction of the successive surface portions from which metal is to be removed; maintaining said streams inclined away from said uncut portion; each of said streams being effective to at least partially oxidize successive surface portions of the metal and blow the same away from the cut in the form of a slag; said stream effecting the last removal of metal being applied adjacent the uncut portion of said surface to produce the sloping edge and deflecting and merging with at least one stream preceding it, whereby said streams cooperate to produce the finished sloping edge.

5. A method of removing heated surface metal from a body to produce a cut having one edge thereof sloping inward from an uncut portion of such surface, which comprises progressively applying at an acute angle to and along said surface a plurality of oxidizing gas streams having the points of impingement thereof in spaced relation; and maintaining said streams at an angle to the direction of such relative movement and inclined away from the uncut portion of said surface; said streams being effective to at least partially oxidize successive surface portions and blow the same ahead of and sideways of the cut; said stream effecting the last removal of metal being applied adjacent the uncut portion of said surface to produce the sloping edge and deflecting so as to merge with at least one gas stream preceding it; said stream effecting the last removal of metal having sufficient velocity to sweep over the surface of the finished cut that is produced.

6. A method of thermo-chemically removing surface metal from a metal body to produce a substantially smooth predetermined contour on a surface thereof, which comprises heating at least a portion of said surface metal to the ignition temperature; simultaneously and progressively applying at least two oxidizing gas streams obliquely against and along such surface; maintaining such streams so related mutually that they merge on the surface to produce and maintain a wet surface film and remove oxidized and molten metal from such portions; relatively moving said gas streams and said body in a direction parallel to said surface; and during such movement maintaining said streams directed each at a different acute angle to said surface and inclined laterally to said direction of movement to control the shape of the surface film and the manner in which it is formed at successive surface portions to produce a surface having a predetermined contour.

7. A method of thermo-chemically removing surface metal from a metal body to produce a substantially smooth predetermined contour on a surface thereof, which comprises heating at least a portion of said surface to the ignition temperature; simultaneously and progressively applying at least two oxidizing gas streams obliquely against and along such surface; maintaining such streams so related mutually that they merge on the surface portions impinged to produce and maintain a wet surface film and remove oxidized and molten metal from such portions; relatively moving said gas streams and said body in a direction parallel to said surface; and during such movement maintaining said streams inclined at different acute angles transversely of the direction of movement and the mutual relation be-

tween said streams such that the respective surface portions removed by each stream merge smoothly and provide a new surface contour free from intermediate ridges.

8. A method of removing heated surface metal from a body to produce a cut having one edge thereof sloping inward from an uncut portion of said surface, which comprises applying obliquely against and along such surface a relatively voluminous oxidizing gas stream so as to remove surface metal; relatively moving said stream and said body in a direction parallel to said surface; and, during such relative movement applying simultaneously another smaller oxidizing gas stream obliquely against portions of surface metal adjacent said uncut portion and inclined away from said uncut portion to produce the sloping edge; said last-mentioned stream being relatively less voluminous and applied at an acute angle to the surface different from the angle of impingement of said first-mentioned gas stream, whereby said streams cooperate to produce a finished sloping edge having a desired smooth contour.

9. A method of removing heated surface metal from a body to produce a cut having one edge thereof sloping inward from an uncut portion of said surface, which comprises applying obliquely against and along such surface a relatively voluminous oxidizing gas stream so as to remove surface metal; relatively moving said stream and said body in a direction parallel to said surface; and, during such relative movement applying simultaneously a second oxidizing gas stream obliquely against portions of surface metal adjacent said uncut portion and inclined away from said uncut portion to produce the sloping edge, said second stream being directed at an angle greater than the angle of impingement of the first-mentioned gas stream so as to cause said second stream initially to penetrate deeply into the surface metal and deflect over the sloping edge and cooperate with said first-mentioned gas stream to produce a finished sloping edge with a predetermined contour having a greater degree of curvature adjacent the uncut portion.

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