July 26, 1938. H. W. JONES 2,125,177

PROCESS FOR REMOVING METAL FROM A SURFACE OF A METAL BODY, AND THE RESULTING PRODUCT

Original Filed Oct. 28, 1933 2 Sheets-Sheet 1

Fig. 1.

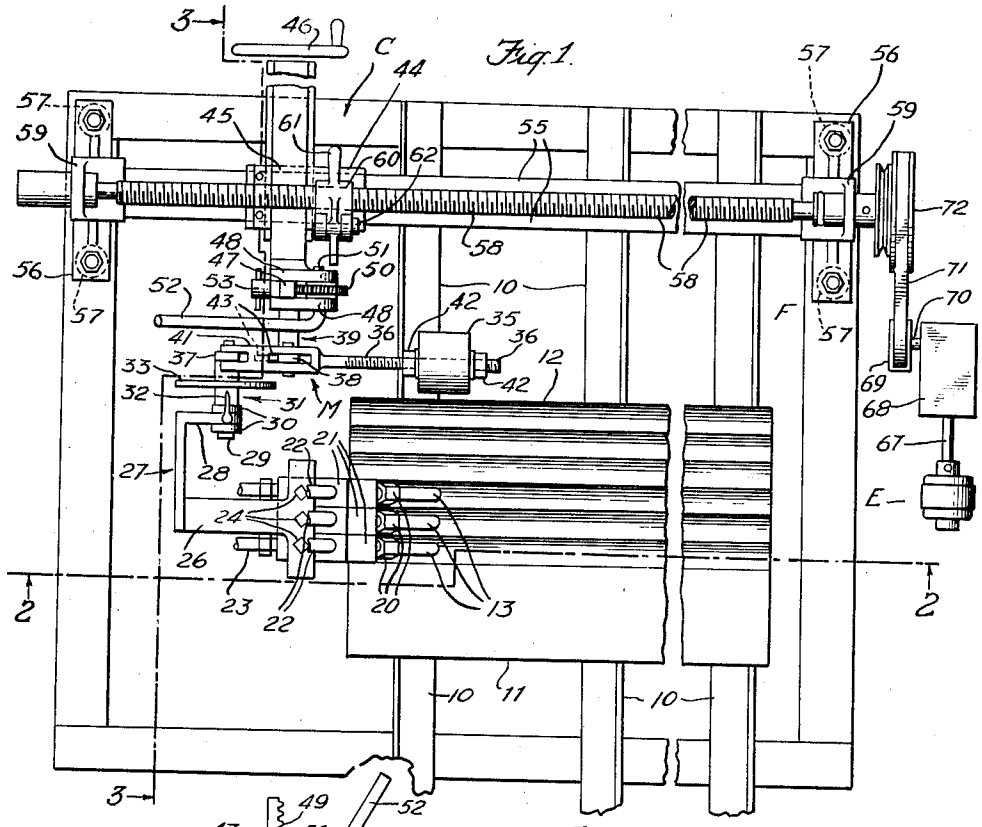


Fig. 2

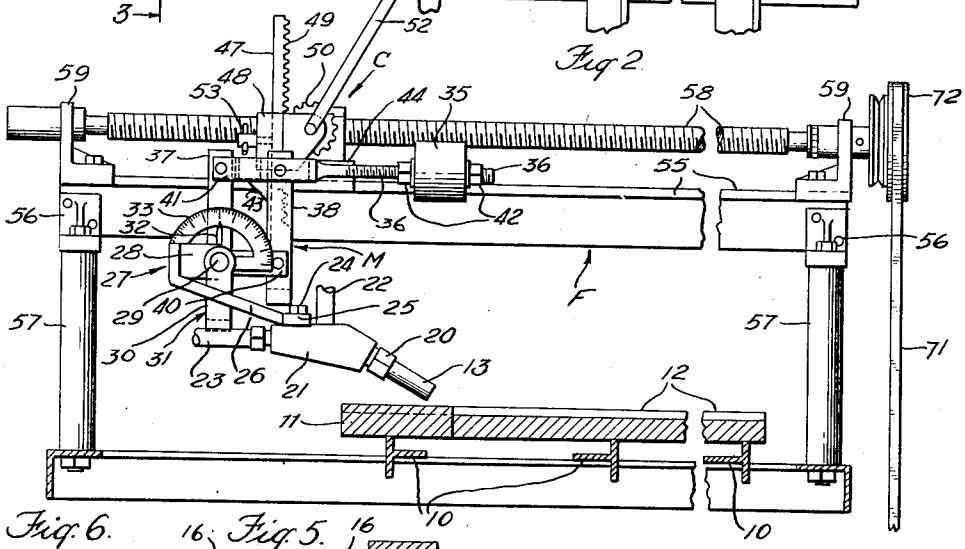


Fig. 6.

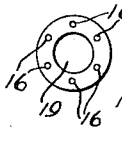
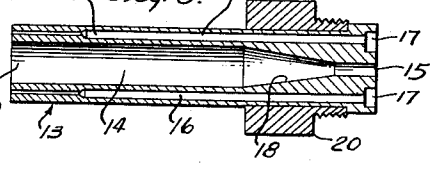


Fig. 5.



INVENTOR.
HOMER W. JONES

BY

ATTORNEY

July 26, 1938. H. W. JONES 2,125,177

PROCESS FOR REMOVING METAL FROM A SURFACE OF A METAL BODY, AND THE RESULTING PRODUCT

Original Filed Oct. 28, 1933 2 Sheets-Sheet 2

Fig. 3

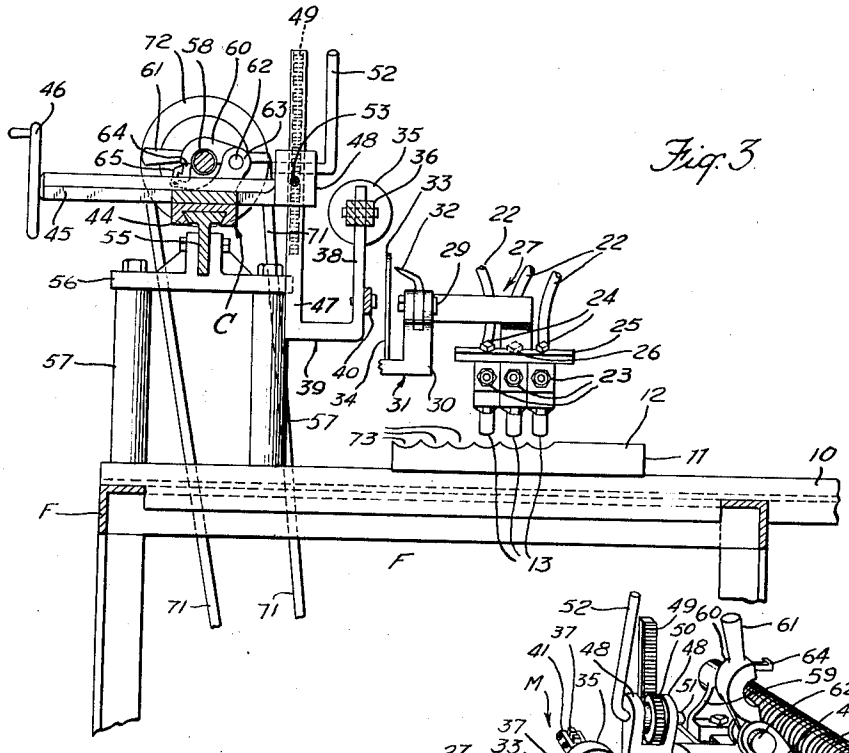
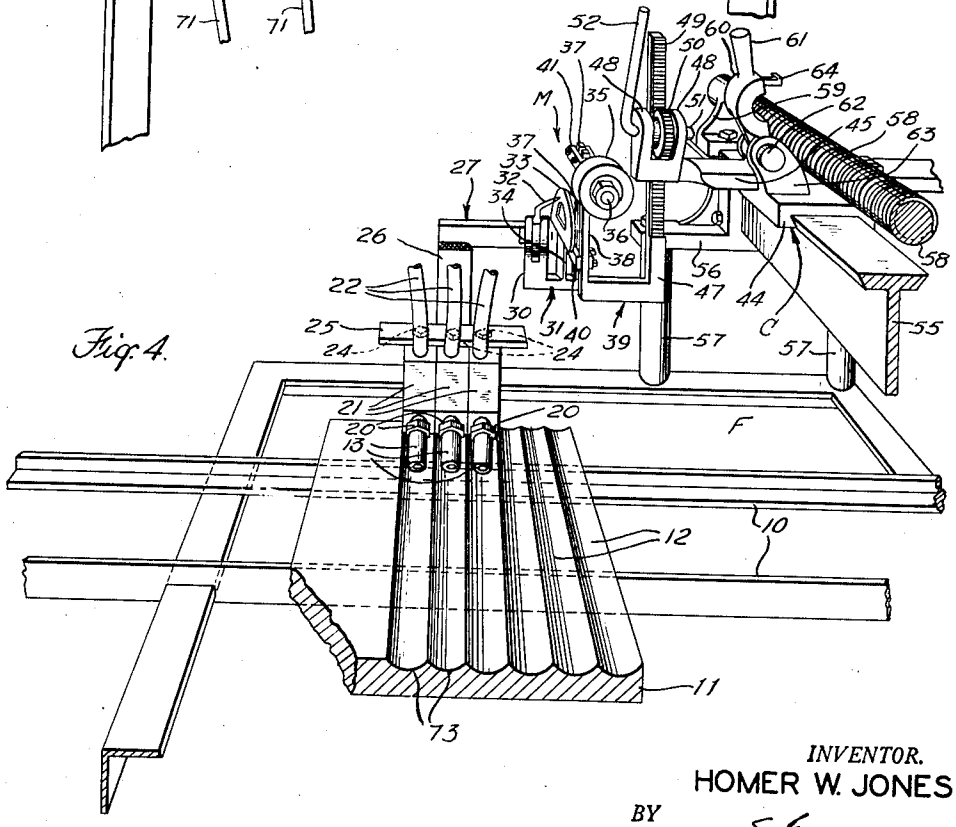


Fig. 4



INVENTOR.
HOMER W. JONES
BY
E. E. Greenewald
ATTORNEY

Patented July 26, 1938 2,125,177

UNITED STATES PATENT OFFICE

2,125,177

PROCESS FOR REMOVING METAL FROM A SURFACE OF A METAL BODY, AND THE RESULTING PRODUCT

Homer W. Jones, Westfield, N. J., assignor, by mesne assignments, to Union Carbide and Carbon Corporation, a corporation of New York

Original application October 28, 1933, Serial No. 695,571. Divided and this application December 29, 1937, Serial No. 182,171

11 Claims. (Cl. 148—9)

My invention relates to a process for thermo-chemically removing surface metal from bodies of ferrous metal such as steel blooms, slabs and billets; and to the resulting products.

It has been the practice heretofore to employ heavy machine tools, such as planing, shaping, milling, and chipping machines, for removing or cutting metal from the surfaces of metallic bodies. Such machines are not entirely satisfactory, because they remove metal at a very slow rate; they are expensive; and their operating costs are high because considerable power is required both for relatively moving the cutting tool and the metallic body and for carrying out a cutting operation. In such machines, also, the greater the hardness of metal the greater is the amount of power required to make a cut.

The objections in using such machines are particularly noticeable in steel mill operations in the manufacturing of steel billets, bars, slabs, and other semi-finished shapes. In the production of such semi-finished shapes surface defects, such as cracks or seams, often occur. These surface defects have generally been removed by such heavy machine tools or by portable chipping tools, and thereafter the semi-finished shapes are rolled.

Within the last few years the objectionable characteristics of heavy machine tools and portable chipping tools have been avoided by employing deseaming blowpipes having nozzles particularly adaptable for removing surface metal from metallic bodies to remove such cracks or seams. These nozzles are constructed so as to permit the passage of a comparatively large volume of oxidizing gas at a relatively low velocity in such a manner that surface metal is removed wherever such cracks or seams are present and cuts or grooves are produced having gradually sloping sides. By making cuts in this manner, the sloping sides of the cuts will tend to flatten out and will not fold over and be rolled into the metallic body upon further rolling thereof.

It has been the practice for an operator to employ a blowpipe of the character just described for manually removing surface metal from metallic bodies. In such cases cuts uniform in character are not attained because many variable factors occur during a manual deseaming operation. These variable factors include the acute angle at which the oxidizing stream is manually applied to the surface of the work, the position that the tip of the blowpipe nozzle is manually held with respect to the work, and the rate of manual movement of the blowpipe nozzle relatively to the work. Also, the maximum economy in the consumption of oxidizing gas is not obtained when seams and cracks are removed manually by an operator. Since many different operating conditions are encountered in practice, it is desirable to provide apparatus and procedure whereby the variable factors mentioned above can be readily correlated and maintained constant during a surfacing operation, in order to remove a shallow uniform layer of surface metal from a steel slab or the like.

An object of my invention, therefore, is to provide an improved process for rapidly and economically removing metal from the surfaces of metallic bodies.

Another object of my invention is to provide a process utilizing an oxidizing gas stream for thermo-chemically removing surface metal from metallic bodies so as to produce improved steel slabs and billets, for example, which have thermo-chemically surfaced portions substantially free from defects, such as cracks and seams, and of substantially uniform character and continuous from adjacent one end to adjacent the opposite end of the slab or billet.

Another object of my invention is to provide a process for removing surface metal with an oxidizing gas stream in which the variable factors encountered are properly correlated and maintained substantially constant during the desurfacing operation, to remove a layer of metal from a surface of a metal body such as a steel slab or billet.

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 is a plan view of apparatus embodying my invention and adapted to perform my improved desurfacing process; Fig. 2 is a sectional view taken on line 2—2 of Fig. 1; Fig. 3 is a sectional view taken on line 3—3 of Fig. 1; Fig. 4 is a perspective view of parts of the apparatus illustrated in Figs. 1 to 3, inclusive; Fig. 5 is a longitudinal cross sectional view of a blowpipe nozzle, preferably employed in the apparatus illustrated in Figs. 1 to 4, inclusive; and Fig. 6 is an end view of the discharge orifice of the blowpipe nozzle shown in Fig. 5.

In desurfacing metal bodies of the character indicated with an oxidizing gas stream a portion of the metal is removed in an oxidized form, and another portion of the metal is removed in

the form of molten metal which, with the oxidized metal, is blown by the oxidizing gas stream forwardly ahead of the region of impingement of said stream against the metal body. To effectively remove surface metal, it must be raised to an ignition or kindling temperature before the oxidizing gas stream is applied thereto. The entire metallic body can be raised to an ignition temperature, as in a furnace, or successive portions of the surface metal to be removed can be progressively raised to an ignition temperature by means of a high temperature flame applied prior to or simultaneously with the application of the oxidizing gas stream. The blowpipe nozzles employed for this purpose discharge a comparatively large volume of oxidizing gas at a relatively low velocity.

The depth and width of cut obtained in any particular case is dependent upon several factors. These factors are the size and velocity of the oxidizing gas stream; the acute angle at which the oxidizing gas stream is applied to the surface of a metallic body; and the rate of relative movement between the oxidizing gas stream and the metallic body. After the size and velocity of the oxidizing gas stream have initially been determined, it is of considerable importance that the oblique angle at which the oxidizing gas stream is applied against the metallic body and the rate of relative movement between the body and oxidizing gas stream be maintained substantially constant, so as to produce channels which are uniform in character and dimension from one end to the opposite end of the body. For this purpose it is desirable to provide apparatus having proper adjustments for applying and maintaining the oxidizing gas stream at a selected acute angle with respect to the surface of the metallic body. Further, it is desirable to provide driving mechanism which can be readily controlled for adjusting and maintaining uniform the rate of relative movement of the oxidizing gas stream and metallic body. In this manner contiguous channels uniform in character are simultaneously obtained with a minimum amount of power and gas.

Referring now to the drawings, the exemplary apparatus here shown comprises a frame structure F having a bed or table 10 upon which the work, such as a steel slab 11, is placed. Where surface metal is to be removed from a large number of duplicate pieces, as in steel mill operations, suitable apparatus may be provided for placing the work on and removing the work from the table 10. Disposed above the slab 11 and at an acute angle to the top surface 12 thereof is arranged a plurality of blowpipe nozzles 13 adapted to move relatively to the slab 11 and continuously from adjacent one end thereof longitudinally in a fixed direction to the other end thereof, for progressively applying heating flames and oxidizing gas streams obliquely against successive portions of the top surface 12 and lengthwise of the latter to remove therefrom a relatively wide layer of surface metal and form contiguous parallel shallow channels of uniform character and dimensions.

In order to remove metal effectively in this manner, it is necessary to employ blowpipe nozzles that will permit the passage of a comparatively large volume of oxidizing gas at a relatively low velocity. The nozzles 13 are of this character and, as shown in Figs. 5 and 6, each comprises a central passage 14 having an inlet 15 for an oxidizing gas, and a plurality of passages 16 surrounding the central passage 14 and having inlets 17 for a combustible gas. To obtain an oxidizing gas stream of large volume and of relatively low velocity, the passage 14 of each nozzle is enlarged at the tapered portion 18 adjacent to the inlet 15, and the remainder of the passage 14 is of the same cross sectional area as the discharge orifice 19. The coupling 20 of each nozzle is threadedly secured to a nozzle head 21 for maintaining the inlet 15 of the oxidizing gas passage 14 and the inlets 17 of the combustible gas passages 16 in communication with similar passages in each head 21. 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, are delivered to the heads 21 through conduits 22 and 23, respectively, from suitable sources of supply (not shown).

When it is desired to remove a narrow strip of surface metal in a single pass, a single nozzle is used; and when it is desired to remove a wide strip of surface metal, a gang or plurality of adjoining nozzles are used. As shown in Figs. 1 to 4, three nozzles 13 are arranged closely side by side or adjacent to each other in a row extending transversely of the length of the surface 12, by securing their respective nozzle heads 21 by cap screws 24 to a crossbar 25. The crossbar 25 is secured to the downwardly sloping arm 26 of a bracket 27, the other arm 28 of which is pivotally mounted by a cap screw 29 in the forked end of an upwardly extending arm 30 of a U-shaped member 31. By pivotally mounting the nozzles 13 on the U-shaped member 31 in this manner, the angle of the nozzles 13 with respect to the top surface 12 of the slab 11 can readily be adjusted. To simultaneously rigidly set the longitudinal axes of all of the nozzles 13 at a given acute angle with respect to the slab 11, the end of the arm 28 of the bracket 27 is provided with a pointer 32 which cooperates with an indicating scale or protractor 33 attached to a projection 34 which is spaced from the arm 30 and secured to the U-shaped member 31, as shown in Fig. 3.

In removing or cutting metal by moving the nozzles 13 relatively to the slab 11, it may be desirable under certain conditions to permit the tips of the nozzles to rest or ride on the bottom of a cut; and under other conditions it may be desirable to maintain the tips of the nozzles 13 spaced from the bottom of a cut, as will be hereinafter explained. When a cut is made with the tips of the nozzles 13 riding in the bottom of a cut, it is not desirable to allow the entire weight of the nozzles 13 and heads 21 to ride in the cut. For this reason, the weight of the nozzles 13 and heads 21 is counterbalanced by mechanism comprising a weight 35 which is slidably mounted on a lever arm 36. The weight 35 counterbalances the major portion of the weight of the nozzles 13 and heads 21 through a parallel linkage M comprising the vertical arm 37 of the U-shaped member 31 and the vertical arm 38 of a U-shaped member 39. The vertical arms 37 and 38 are arranged in spaced relation and form the vertical links of the linkage M, and are pivotally connected at their lower ends to a horizontal link 40. The upper ends of the vertical arms 37 and 38 are pivotally connected in the forked end 41 of the lever arm 36, which forked end forms the upper horizontal link of the linkage M. By properly positioning the counterweight 35 at the threaded outer end of the lever arm 36 by lock nuts 42 which bear against each

end of the counterweight, the weight of the nozzles 13 and heads 21 can be readily counterbalanced, so that the tips of the nozzles 13 will bear lightly on the bottom of a cut as the nozzles are moved relatively to the slab 11. This tends to minimize the friction and chattering between the nozzles 13 and the surface 12 of the slab 11. In cases where the work is not perfectly flat and the nozzles tend to move up and down as they are translated with respect to the work, the given acute angle at which the nozzles 13 are set will always remain the same, due to the reciprocatory parallel motion of the vertical links of the parallel linkage M.

In order to limit the downward movement of the nozzles 13 when it is desired to make cuts with the tips spaced from the bottom of a cut, the arm 38 of the U-shaped member 39 is provided with a projection or stop 43 shown in Figs. 1 and 2 which is adapted to contact with the lever 36 and raise the nozzles from the slab 11 when the arm 38 is moved by a mechanism to be described.

The nozzles 13 and the parts of the apparatus just described and cooperating therewith are mounted on a carrier or carriage C having mechanisms for adjusting the nozzles 13 transversely and vertically with respect to the slab 11. The carriage C comprises a base plate 44 and a slide 45 in dove-tailed engagement therewith and movable laterally of the frame structure F by mechanism on the carriage C which is actuated by turning a handwheel 46. The vertical arm 47 of the U-shaped member 39 extends through an opening of a guide block 48 which is secured to the end of the slide 45 opposite the hand-wheel 46. On the vertical arm 47 is formed a toothed rack 49 which engages a pinion 50. The pinion is secured to a shaft 51 journaled in the guide block 48. A right angle extension 52 on the shaft 51 serves as a handle which, when turned, rotates the pinion 50 so as to move the toothed rack 49 and the arm 38 of the U member 39 up or down. The stop 43 carried by the arm 38 strikes the lever 36 and adjusts the nozzles 13 vertically with respect to the slab 11. The nozzles 13 can be maintained at a given vertical position by locking the arm 47 in the guide block 48 by a set screw 53, as shown in Fig. 2.

The base plate 44 of the carriage C is in dovetailed engagement with and movable along a T-shaped rail 55 extending longitudinally of the frame structure F, the ends of which rail are fixed in brackets 56 attached to standards 57 mounted on the frame structure F. Above and parallel to the rail 55 is arranged a lead screw 58 for driving the carriage C, the ends of which are journaled in brackets 59 attached to the ends of the rail 55. A cap 60 internally threaded to form a half nut for operatively connecting the carriage C to the lead screw 58 is provided with a handle 61 which is pivotally connected at 62 to a forked arm 63 attached to the base plate 44. To maintain the cap 60 in a downward and engaged position with the lead screw 58 it is provided with a notched lug 64, as shown in Figs. 3 and 4, which lug is adapted to be engaged by a pawl 65 pivotally mounted on the base plate 44 and resiliently biased, as by a spring (not shown), toward the lug 64.

The lead screw 58 is arranged to be driven by an electric motor E having a shaft 67 connected to a variable speed change device 68. A pulley 69 secured to a shaft 70 of the speed change device 68 drives a belt 71 which is connected to a pulley 72 secured to one end of the lead screw 58. By providing the speed change device 68, the carriage C can be driven at any desired speed by the lead screw 58. In this manner the obliquely inclined nozzles 13 can be moved at a constant and proper rate of speed longitudinally of the surface 12 to produce cuts which are substantially uniform throughout their lengths.

The operation of the apparatus illustrated in the drawings is substantially as follows: It will be assumed that the motor E is energized and the speed change device 68 has been so adjusted that the carriage C will be driven at the desired speed by the lead screw 58; that the cap 60 on the carriage C is disengaged from the lead screw 58; that the carriage C is at the left hand end of the frame structure F with the nozzles 13 clear of the slab 11; that the nozzles 13 have been correctly positioned laterally by turning the handwheel 46; that the nozzles 13 have been adjusted at the desired acute angle with respect to the slab 11; that the handle 52 has been turned to adjust the nozzles 13 vertically with respect to the surface 12 of the slab; that the position of the counterweight 35 has been adjusted on the lever arm 36 so that the nozzles 13 will lightly ride the bottom of the cut; and that the conduit 23 is supplied with a mixture of oxygen and acetylene. With the above assumed conditions, the combustible gas issuing from the passages 16 is ignited and the carriage C is moved manually so that the row of adjoining heating flames will be applied to the left hand edge of the slab 11. As soon as a wide transverse zone adjacent the edge of the slab 11 has reached an ignition temperature, oxygen is supplied to the conduits 22 and the cap 60 is turned to its downward position so that the carriage C will be engaged and driven by the lead screw 58. The row of adjoining oxidizing gas streams issuing from the orifices 19 of the nozzles 13 will then oxidize a relatively wide transverse zone of the surface metal at the left hand edge which has been raised to an ignition temperature by the heating flames, and this oxidized metal along with molten metal will be blown ahead of the nozzles 13 in the form of a slag by the force of the oxidizing gas streams.

Since it was assumed that the nozzles 13 will ride the bottom of the cut, the carriage C in being driven by lead screw 58 will cause the tips of the nozzles 13 to move on the bottom of the cut started at the left hand edge of the slab 11. The nozzles 13 are moved relatively fast over the surface 12 of the slab 11 with the heating flames, together with the molten metal and oxides, raising relatively wide successive surface portions to an ignition temperature, and with the oxidizing gas streams oxidizing the successive surface portions which have been raised to an ignition temperature. During the entire operation, oxidized and molten metal are blown or propelled ahead and away from the cut, and progressively forwardly onto the surface to be removed, by the force of the oxidizing gas streams. The several oxygen or oxidizing gas streams issuing from the orifices 19 effect superficial metal combustion along a relatively wide transverse zone of the surface of the slab 11 and, during the movement of the nozzles 13 longitudinally of the surface, the volume, velocity, and angle of impingement of the oxygen streams as well as the rate of such movement are so correlated

as to maintain such superficial metal combustion on successive surface zones from one end of the slab 11 to its opposite end, to produce continuous and uniform thermo-chemical removal of a wide shallow layer of metal from said surface throughout the entire length of the latter. Furthermore, the shape of the oxidizing gas stream or streams and the number of the longitudinal relative motions of said stream or streams and the slab or other body 11 are correlated to effect thermo-chemical metal removal from the full width of a surface of said body.

When the cut has been completed, to the right hand edge of the slab 11, the cap 60 is disengaged from the lead screw 58, and the carriage C is moved to the left hand end of the frame structure F. For making a cut parallel to the cut just completed, the nozzles 13 are moved transversely of the frame structure F by turning the handwheel 46 which actuates the mechanism for moving the slide 45 laterally of the carriage C. Although I have described a cut started at one edge of the slab 11, it is to be understood that cuts may be started at points intermediate the edges of the slab.

In the description of the operation of the apparatus, it has just been stated that the oxidizing gas streams blow oxidized and molten surface metal progressively forwardly onto the untreated surface, and this mixture of oxidized and molten surface metal has been termed a "slag". Although the surface metal removed can be reduced completely to an oxidized form, it has neither been desirable nor necessary to do so in practice. For example, it has been calculated that approximately 4⅔ cubic feet of oxygen are required to oxidize completely one pound of an ordinary grade of low carbon steel containing about .2% carbon. In actual practice it has been possible to remove a pound of this steel with approximately 2 cubic feet of oxygen. It is therefore apparent that a portion of the surface metal removed is in an oxidized state, and that the remaining portion is in a partially oxidized state and in an unoxidized state or molten form. By removing a substantial portion of the surface without completely oxidizing the same, considerable economy can be effected in the amount of oxidizing gas required to remove or make cuts in the surfaces of metallic bodies.

The removed metal blown ahead in advance of the cut as it is being made is at a high temperature and serves to assist the thermo-chemical action by preheating successive portions of the surface metal to which the oxidizing stream is subsequently applied and thereby greatly contributes to the efficiency of the process. The characteristic types of cuts made in this manner are smooth shallow parallel contiguous channels or grooves having gradually sloping sides, as indicated at 73 in Figs. 3 and 4.

Due to the slight amount of friction and chattering between the tips of the nozzles and the surface of a metallic body, the cuts ordinarily made when the tips of the nozzles are riding in the bottom of a cut are usually not glass smooth. In normal production work these cuts are sufficiently smooth for all practical purposes. In certain instances, however, it is desirable to produce particularly smooth cuts. In order to make cuts which are extremely smooth, the nozzles 13 are adjusted so that their tips may be spaced from the bottom of a cut. This is accomplished by providing the stop 43 to limit the downward movement of the nozzles 13 after they have been positioned vertically by turning the handle 52. Although smoother cuts are obtained when the tips of the nozzles are spaced from the bottom of a cut, it is considerably more economical to remove metal with the nozzles riding the bottom of a cut, because in the latter case less oxidizing gas is required to remove a pound of metal, other factors remaining substantially the same.

It has been stated that the nozzles 13 are of such a type that they will permit the passage of a comparatively large volume of oxidizing gas at a relatively low velocity. In practice it has been determined that the best results under average conditions are obtained in most cases when the pressure of the oxidizing gas is adjusted to produce an oxidizing gas stream having a velocity between 550 and 750 feet per second. However, higher or lower oxidizing gas stream velocities may be used to suit different conditions and results desired.

The velocities of the oxidizing gas streams herein are calculated velocities of the oxidizing jets discharged from the nozzles based on the assumption that a measured volume of gas discharge in a given time has a temperature of 70° F. and is at atmospheric pressure.

The depth of the cut or channel and the height of the ridges may be made more or less pronounced than illustrated to suit the working conditions. The depth and width of a cut are affected by the velocity of the oxidizing gas stream, both the depth and width of a cut increasing with an increase in the velocity of the oxidizing gas stream. The depth and width of a cut can partially be controlled, therefore, by adjusting the velocity of the oxidizing gas stream. The dimensions of a cut can also be controlled to some extent by varying the angle of the nozzles with respect to the work. It has been found that the depth of a cut does not change appreciably with a change in the angle of a nozzle. However, when the angle of a nozzle is increased with respect to the work, a marked increase is obtained in the width of a cut. By way of example, satisfactory cuts have been made with nozzles adjusted at acute angles not greater than about 35 degrees and varying from about 10 to about 35 degrees with respect to the surface of the work. Since wider cuts are obtained when the nozzles are set at the higher angles, the amount of metal that can be removed per cubic foot of oxidizing gas can be increased by increasing the acute angle of the nozzles with respect to the work.

It has been mentioned above that the nozzles 13 are moved relatively fast over the surface of the slab 11. Generally, the depth and width of a cut will decrease with an increase in the speed at which the nozzles 13 are moved relatively to the work. For different speeds at which the nozzles 13 are moved, the amount of metal removed per pound of oxidizing gas is substantially the same. In any particular case, in order to economize time, the nozzles are preferably moved at the maximum speed which will still give a cut of the desired depth and width. The rate of movement of the nozzles relatively to the surface operated upon is always substantially higher than the maximum speed heretofore conventionally employed for severing metal by means of oxygen jets. At very low speeds, of the magnitude heretofore employed for severing metal with oxygen jets, satisfactory desurfacing cuts are not obtained due to the digging tendency of the oxidizing gas stream. This digging or piercing

is caused by the metal slag piling up ahead of the nozzle. In order to avoid the oxidizing gas stream digging into the surface of the work, the nozzle is propelled at a speed sufficient to prevent the oxidizing gas stream being applied for too long a time at any particular portion of the surface of the work. By way of example, satisfactory desurfacing cuts have been made on cold metal by propelling the nozzles at speeds varying from 4 to 90 feet per minute, i. e. at a uniform rate of speed higher than the maximum speed heretofore conventionally employed for severing metal by means of an oxygen jet. For example, when using well known high-velocity oxygen jets for cutting or severing mild or structural steel at room temperature, conventional machine cutting speeds for propelling the cutting nozzle or blowpipe relatively to the steel body vary from about 2.4 inches per minute for steel of 12 inches thickness to about 32 inches per minute for steel of one-eighth inch thickness. From the viewpoint of saving time and conserving heat it is particularly advantageous to remove the surface metal from the billets, slabs, or the like while they are at elevated temperatures, such as the temperature of a steel slab or billet after being hot rolled to reduce its cross section. In the case where surface cracks are found by visual inspection of the metal and the deseaming has been accomplished by manual methods, it has been necessary to allow the metal to cool before the surface defects can be removed individually. With the use of my improved apparatus no visual inspection for cracks or other surface defects is necessary when the entire surface is removed, and since it is not necessary that the operator approach the metal closely, the surface metal may be removed very rapidly while at the temperature of rolling or even higher. Where the preheated metal is at an insufficient temperature to ignite in the oxidizing gas stream it is necessary to preheat the metal additionally to start the cut but such preheat may be discontinued after the cut has been started.

In any event the residual heat in the metal at a hot rolling temperature favors employing a very rapid desurfacing speed (materially above the maximum speed for desurfacing cold metal) and effects an economy in the use of the gases although on heated metal, in some instances, a more economical use of the oxidizing gases may be effected by simultaneously preheating such hot metal and applying the oxidizing gas stream thereto. The preheat is preferably applied in the form of a gas flame.

It has also been observed that relatively hard metal, such as steels having high amounts of combined carbon, respond more readily to the action of oxidizing gas streams than metals of lower hardness, such as the low carbon steels. Since the harder metals respond more readily to the action of an oxidizing gas stream than metals of lower hardness, the cost of removing surface metal does not increase with the hardness of the metal cut, as is the case with the heavy machine tools heretofore used where the amount of power required to make a cut increases with the hardness of the metal.

It will thus be seen that an improved and inexpensive apparatus which may be made relatively light in weight, as compared with machines heretofore used, has been provided for economically performing this improved process of removing or cutting metal from the surfaces of metallic bodies. Since the apparatus is light and the friction between the cutting nozzles and the work is very small or may be eliminated, very little power is required for moving the nozzles relatively to the work. By providing various adjustments for the blowpipe nozzles, the manner in which the oxidizing gas is applied on the surface of the work can be readily controlled to produce cuts of any desired depth, width, and finish. After these various adjustments have been initially made, such as the setting of the nozzles at a particular acute angle and the speed at which the nozzles will travel, cuts uniform in quality are obtained. In addition to obtaining uniform cuts, the different adjustments can be so made that cuts can be produced with a minimum consumption of oxidizing gas, thereby effecting considerable economy in operating costs.

While I have shown and described a particular embodiment of my invention, it will be apparent that the gas streams may be caused to traverse the surface of the metal body by moving either the gas stream or the metal body, one relatively to the other, and that many modifications may be made without departing from the scope of my invention as set forth in the appended claims.

This application is a division of my application Serial No. 695,571, filed October 28, 1933.

I claim:

1. In a process of thermo-chemically removing a shallow layer of metal from a hot surface of a ferrous metal body, such as a steel slab or billet, in combination, applying a voluminous and relatively low-velocity stream of oxidizing gas at an angle obliquely against said surface, said stream having a relatively wide but narrow cross-section adjacent the area of impingement so as to effect superficial combustion of metal over a relatively wide area transversely of said surface, effecting continuous relative motion of said body and said stream longitudinally of said body at a uniform rate, and correlating the volume, velocity and angle of impingement of said stream and the rate of said relative motion to maintain combustion of superficial metal for providing continuous, shallow, thermo-chemical surface removal longitudinally of said body.

2. A process of thermo-chemically removing a layer of metal from a surface of a metal body, such as a steel slab or billet, which comprises continuously applying a high temperature heating flame and a relatively low-velocity oxygen stream obliquely against and lengthwise of said surface while effecting continuous relative motion between said body and said flame and stream in a fixed direction longitudinally of said surface and at a uniform rate higher than that conventionally employed for severing metal by means of an oxygen jet, to effect superficial metal combustion on successive surface portions against which said flame and stream impinge; during such relative motion maintaining substantially constant the oblique angle of impingement of said stream against said surface; correlating the volume, velocity and angle of impingement of said stream and the rate of said relative motion to maintain such combustion of superficial metal to produce continuous and uniform thermo-chemical removal of metal from said surface throughout the entire length of the latter; and correlating the shape of said stream and the number of the longitudinal relative motions of said stream and body to effect such metal removal from the full width of said surface of said body.

3. A process of thermo-chemically removing a layer of metal from a surface of a ferrous metal

body, such as a steel slab or billet, which is at a temperature of hot rolling, such process comprising applying a voluminous low-velocity stream of oxidizing gas obliquely against such hot surface adjacent one end thereof to effect superficial metal combustion along a zone of said surface adjacent said end; effecting continuous relative motion between said body and said stream at a uniform rate and in a fixed direction longitudinally of said surface toward the other end of the latter; during such relative motion, maintaining substantially constant the oblique angle of impingement of said stream and correlating the volume, velocity and angle of impingement of said stream and the rate of such relative motion to maintain such superficial metal combustion on successive surface zones and to continuously blow metal oxide and molten metal so produced onto said surface ahead of the region of impingement of said stream against said surface; and correlating the shape of said stream and the number of longitudinal relative motions of said stream and body to effect such metal removal from the full width of said surface of said body.

4. A process of thermo-chemically removing a layer of metal of substantially uniform width from a surface of a metal body, such as a steel slab or billet, which comprises applying a relatively wide high-temperature flame against a relatively wide transverse portion of said surface adjacent one end thereof to initially heat said portion to a kindling temperature; applying a voluminous and relatively wide low-velocity stream of oxidizing gas obliquely against such initially heated portion and lengthwise of said surface toward the other end thereof; effecting continuous relative motion between said body and said stream, in a fixed direction longitudinally of said surface and at a uniform rate higher than that conventionally employed for severing metal by means of an oxygen jet, while continuously applying said flame against successive portions of said surface and while said stream is continuously applied obliquely against such successive portions and blows metal oxide and molten surface metal, produced by the resulting thermo-chemical action, ahead of the region of impingement of said flame and said stream against said surface; and, during such relative motion from one end to the other end of said surface, maintaining constant and at a value not greater than 35 degrees, the oblique angle of impingement of said stream against said surface.

5. A process of thermo-chemically removing a relatively wide layer of metal from a surface of a metal body, such as a steel slab or billet, which comprises heating at least a portion of said surface; simultaneously applying a row of adjoining voluminous low-velocity oxygen streams obliquely against such heated surface portion to effect superficial metal combustion along a relatively wide transverse zone of said surface; effecting continuous relative motion at a uniform rate between said body and said oxygen streams while continuously applying said streams obliquely against said surface; and correlating the volume, velocity and angle of impingement of said streams and the rate of said relative motion to maintain superficial metal combustion and thereby thermo-chemically remove a relatively wide layer of metal from said surface.

6. A process of thermo-chemically removing metal from a surface of a hot metal body at a hot rolling temperature, such as a hot steel slab or billet, which comprises simultaneously applying obliquely against such hot surface a plurality of streams of oxidizing gas disposed side by side in a row; effecting relative motion at a uniform rate between said body and such row of streams while the latter are applied obliquely against said hot surface; and, during such relative motion, maintaining constant the oblique angles of impingement of said streams against said body, thereby producing on said body a new surface consisting of a plurality of contiguous parallel shallow channels equal in number to said plurality of streams.

7. A process of thermo-chemically removing a relatively wide shallow layer of metal from a surface of a ferrous metal body, such as a steel slab or billet, which comprises simultaneously applying a row of adjoining high temperature flames and a row of adjoining low-velocity voluminous oxygen streams obliquely against a relatively wide transverse zone of said surface to effect superficial metal combustion along said zone; effecting continuous relative motion, between said body and such rows of flames and streams, at a uniform rate and in a fixed direction longitudinally of said surface to apply said flames and streams obliquely against successive transverse zones of said surface; and correlating the velocity, volume and angle of impingement of said oxygen streams and the rate of such relative motion to maintain superficial metal combustion transversely of said surface as said flames and streams are applied to such successive zones during such motion to remove a wide shallow layer of metal from said surface.

8. A process of thermo-chemically removing a wide shallow layer of metal from a surface of a ferrous metal body, such as a steel slab or billet, which comprises supporting said body in a position to be operated upon; applying a row of adjoining high temperature flames against a relatively wide transverse zone of said surface adjacent one end thereof to initially heat said zone to a kindling temperature; applying obliquely against such heated zone a plurality of adjoining low-velocity voluminous oxidizing gas streams disposed side by side in a row extending transversely of said surface to effect superficial metal combustion at said zone; moving said flames and said streams in unison lengthwise of said surface to the other end thereof while applying said flames and streams to successive zones of said surface; and correlating the volume, velocity and angle of impingement of said streams and the rate of such movement to maintain superficial metal combustion transversely of said surface as said flames and said streams are applied to such successive zones during such movement.

9. A process of thermo-chemically removing a relatively wide layer of metal from a surface of a metal body, such as a steel slab or billet, which comprises applying a row of high temperature flames against a relatively wide transverse portion of said surface adjacent one end thereof to initially heat said portion to a kindling temperature; then starting at such initially heated portion and simultaneously applying, obliquely against and lengthwise of said surface toward the other end thereof, a plurality of low-velocity voluminous streams of oxidizing gas disposed side by side in a row extending transversely of the length of said surface; effecting continuous relative motion, between said body on the one hand and said row of flames and said row of streams on the other hand, at a uniform rate and in a

direction longitudinally of said surface to the other end thereof while applying said row of flames against successive portions of said surface and while progressively applying said row of streams obliquely against such successive portions and blowing metal oxide and molten metal, produced by the resulting thermo-chemical action, ahead of the region of impingement of said flames and said streams against said surface; and, during such relative motion from one end to the other end of said surface, maintaining constant and at a value not greater than 35 degrees, the oblique angles of impingement of said streams against said surface, to produce on said body a new surface comprising a plurality of shallow parallel contiguous channels, each of substantially uniform dimensions and extending from adjacent one end to adjacent the other end of said body.

10. A thermo-chemically surfaced ferrous metal body, such as a steel slab or billet, having a surface portion consisting of contiguous parallel shallow channels produced by thermo-chemically removing metal from a surface of said body by the application of voluminous relatively low-velocity oxidizing gas streams against said surface when at ignition temperature.

11. A thermo-chemically surfaced ferrous metal body, such as a steel slab or billet, having a surface portion substantially free from superficial defects such as cracks and seams and consisting of contiguous parallel shallow channels extending continuously from adjacent one end of said body to adjacent the other end of the same, said channels having sides sloping gradually to ridges severally defining the contiguous boundaries of said channels and produced by the application of voluminous relatively low-velocity oxidizing gas streams against said surface when at ignition temperature.

HOMER W. JONES.