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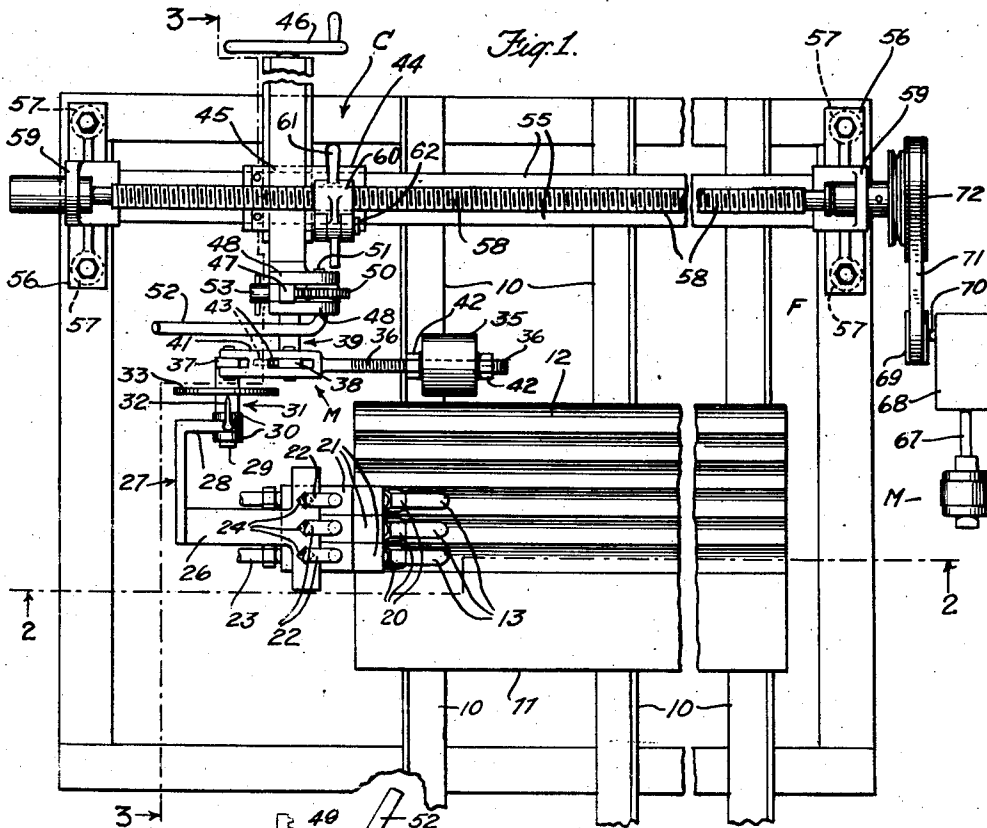
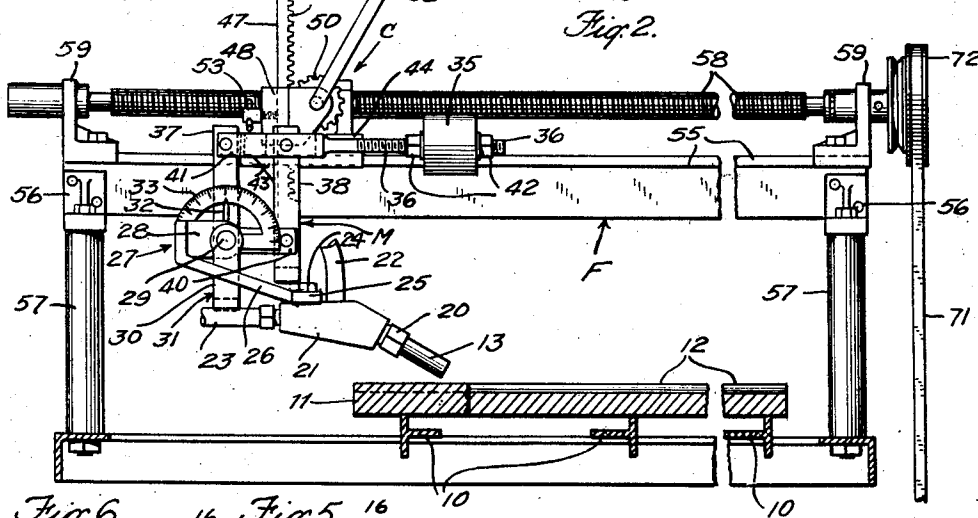
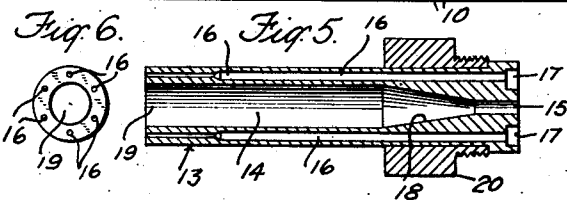
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2,125,176

APPARATUS FOR REMOVING METAL FROM THE SURFACES OF METALLIC BODIES

Filed Oct. 28, 1933

2 Sheets-Sheet 1



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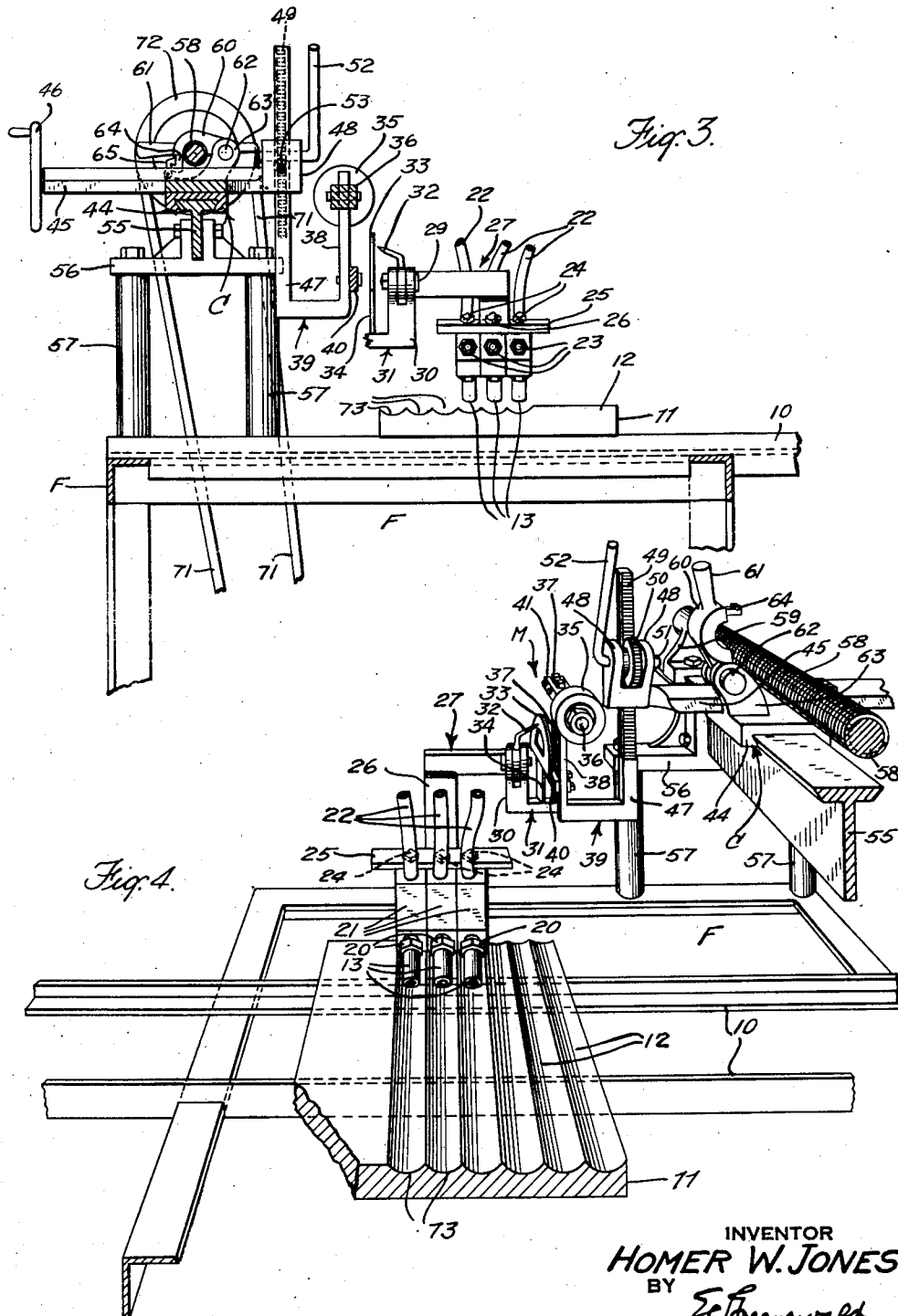
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

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APPARATUS FOR REMOVING METAL FROM
THE SURFACES OF METALLIC BODIESHomer W. Jones, Elizabeth, N. J., assignor, by
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bon Corporation, a corporation of New York

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18 Claims. (Cl. 266—23)

My invention relates to an apparatus for thermo-chemically removing surface metal from bodies of ferrous metal such as steel slabs and billets.

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. Further, they are expensive, and their operating costs are high because 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 these machines are particularly true in steel mill operations in the manufacturing of steel billets, bars, slabs, and other semi-finished shapes. In the manufacturing of such semi-finished shapes surface defects, such as cracks or seams, are often produced. These surface defects have generally been removed by portable chipping tools and heavy machine tools, and thereafter the semi-finished shapes are rolled.

Within the last few years the objections of heavy machine tools have been avoided by employing blowpipes having nozzles particularly adaptable for removing surface metal from metallic bodies. 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 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 surface removing operation. These variable factors include the acute angle at which the oxidizing stream is applied to the surface of the work, the position of the tip of the blowpipe nozzle with respect to the work, and the rate of relative movement between the blowpipe nozzle and the work. Also, the maximum economy in the consumption of oxidizing gas is not obtained when surface metal is removed manually by an operator. Since

many different operating conditions are encountered in practice, it is desirable to provide apparatus in which the variable factors mentioned above can be readily changed and maintained constant during the surfacing operation.

An object of my invention, therefore, is to provide an improved apparatus relatively light in weight as compared with heavy machine tools for rapidly and economically removing metal from the surfaces of metallic bodies.

Another object of my invention is to provide an apparatus utilizing an oxidizing gas stream for thermochemically removing surface metal from metallic bodies so as to produce improved steel slabs and billets, for example, which have surface 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 apparatus for removing surface metal with an oxidizing gas stream in which the variable factors encountered can be controlled 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.

A further object of my invention is to provide such apparatus wherein the manner of applying an oxidizing gas stream can readily be changed for different operating conditions.

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 ox-

dized metal, is blown by the oxidizing gas stream forwardly ahead of the region or zone 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 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 bodies and the rate of relative movement between the bodies and oxidizing gas stream be maintained substantially constant, so as to produce channels which are uniform in character and dimension. 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 a 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 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 and lengthwise of successive portions of the top surface 12 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 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 surface 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 75

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.

5 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
10 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
15 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 de-
20 scribed.

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
25 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
30 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 handwheel 46. On the vertical arm 47 is formed a toothed
35 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
40 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
45 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 dove-tailed engagement with and movable along a T-shaped rail 55 extending longitudinally of the
50 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
55 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
60 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
65 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
70 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
75 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
5 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 adjust-
10 ed 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
15 13 clear of the slab 11; that the nozzles 13 have been correctly positioned laterally by turning the hand-wheel 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
20 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
25 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 ad-
30 joining 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
35 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
40 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
45 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
50 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
55 flames, together with the molten metal and oxides, raising 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 tempera-
60 ture. During the entire operation, oxidizing and molten metal are blown or propelled ahead and away from the cut, and progressively onto the surface to be removed, by the force of the oxidizing gas streams. The several oxygen or oxidizing
65 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
70 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
75 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.

When the cut has been completed, 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 or necessary to do so in practice. For example, it has been calculated that approximately $4\frac{2}{3}$ 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 reaction 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 apparatus and 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 given 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 10 to 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. At very low speeds satisfactory 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 nozzles at speeds varying from 4 to 90 feet per minute, i. e., at a 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 descaling 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 metals, 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 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 has been divided, the process and product herein disclosed being claimed in my application, Serial No. 182,171, filed Dec. 29, 1937.

I claim:

1. In apparatus for thermo-chemically desurfacing bodies of ferrous metal, the combination with means for supporting a body in a position to be operated upon, of a gang of blowpipe nozzles adjustably mounted adjacent the surface to be removed, said nozzles being each adapted to ride in a channel which is formed on the body and positioned to be inclined constantly at an angle between 10 and 35 degrees to the direction on said surface in which it is to advance and provided with separate passages for oxidizing gas and heating gas, means for holding said nozzles rigidly in side-by-side relation, means for yieldingly holding said nozzles in a desired position with respect to said surface, and means for effecting relative motion between said body and said nozzles at a rate removing a relatively thin stratum of surface metal to substantially uniform depth along a channel.

2. In apparatus for thermo-chemically desurfacing bodies of ferrous metal, the combination with means for stationarily supporting a body in a position to be operated upon, of a carriage movably supported with respect to said supporting means, a gang of blowpipe nozzles adjustably mounted on said carriage in a manner adapted to be moved adjacent to the surface to be removed, said nozzles each being adapted to ride in a channel and positioned to be inclined constantly at an angle between 10 and 35 degrees to the direction on said surface in which it is to advance and provided with separate passages for oxidizing gas and heating gas, the oxidizing gas passage of each nozzle being shaped to supply a relatively large volume of low velocity oxidizing gas, adjustable means for holding said nozzles rigidly in side-by-side relation, adjustable means for yieldingly holding said nozzles in a desired position with respect to said surface, and means for moving said carriage whereby said gang may traverse said surface in one or more passes to effect a desurfacing operation.

3. A machine for surfacing metal bodies including in combination a carriage, an arm connected to and extending transversely of the carriage, a frame carried by the arm adjacent one end of the arm, torch holders on the frame for supporting torches, means for causing the arm to move transversely of the carriage to position said frame over a body to be surfaced, and means for raising and lowering the frame to control the spacing of the torches from the surface of the body.

4. A machine for surfacing metal bodies comprising a base, a transversely extending arm, a support for said arm connected with the base, a frame depending from one end of the arm beyond the base, holders on the frame for supporting torches in position to surface a body alongside the base, means on the arm support for causing the arm to move transversely to locate the torches at the desired spacing from the side of the base, and other means on the arm support for raising and lowering the frame to control the

spacing of the torches from the body to be surfaced.

5. Apparatus for thermo-chemically removing a shallow layer of metal from a surface of a ferrous metal body, such as a steel slab or billet, such apparatus comprising, in combination, nozzle means for delivering a high temperature heating medium and a low-velocity voluminous oxygen stream of relatively narrow and long cross-section obliquely against said surface to effect superficial metal combustion along a relatively wide transverse zone of said surface; and mechanism for effecting continuous relative motion of said nozzle means and said body lengthwise of said surface at a rate higher than that conventionally employed for severing metal by means of an oxygen jet; the volume, velocity and angle of impingement of said stream and said rate of relative motion being so correlated as to maintain such combustion of superficial metal during such movement to produce continuous thermo-chemical removal of a shallow layer of said surface longitudinally of said body.

6. Apparatus for thermo-chemically removing a substantially uniform shallow layer of metal from a longitudinal surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of blowpipe nozzle means constructed to deliver a voluminous low-velocity stream of oxidizing gas obliquely against said surface while the latter is heated to an ignition temperature, to effect superficial metal combustion along a transverse zone of said surface; a carriage carrying said nozzle means; mechanism whereby said nozzle means is movable relatively to said carriage toward and away from, and transversely of, said surface; adjustable means for setting said nozzle means to deliver said stream at a selected oblique angle relatively to the plane of said surface; and propelling mechanism for effecting continuous relative motion, between said body and said carriage carrying said nozzle means, at a uniform rate higher than that conventionally employed for severing metal by means of an oxygen jet and in a fixed direction longitudinally of said surface from adjacent one end thereof to the opposite end thereof while maintaining constant such oblique angle position of said nozzle means and said stream relatively to the plane of and adjacent to said surface, to continuously maintain such superficial metal combustion during such relative motion and remove a substantially uniform shallow layer of metal from said surface.

7. Apparatus for thermo-chemically removing a substantially uniform layer of metal from a longitudinal surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a blowpipe nozzle constructed to deliver a voluminous low-velocity stream of oxidizing gas obliquely against and lengthwise of said surface; a carrier for said nozzle; mechanism whereby said nozzle is movable relatively to said carrier toward and away from, and transversely of, said surface; adjustable means for setting said nozzle to deliver said stream at a selected oblique angle, of a value not greater than 35 degrees, relatively to the plane of said surface; and mechanism for effecting continuous relative motion between said body and said carrier with said nozzle, at a uniform rate higher than that conventionally employed for severing metal by means of an oxygen jet and in a fixed direction longitudinally of said surface from adjacent one end thereof to the opposite end there-

of while maintaining constant such oblique angle position of said nozzle and said stream relatively to the plane of and adjacent to said surface, to continuously remove metal from said surface and blow metal oxide and molten metal, produced by the resulting thermo-chemical action, ahead of the region of impingement of said stream against said surface; said mechanism whereby said nozzle is movable toward and away from said surface comprising means normally holding said nozzle adjacent to said surface and adapted to yield in response to irregularities of said surface to permit said nozzle to move away from said surface without changing said oblique angle position of said nozzle and said stream relatively to the plane of said surface.

8. Apparatus for thermo-chemically removing a substantially uniform layer of metal from a longitudinal surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a blowpipe nozzle constructed to deliver a voluminous low-velocity stream of oxidizing gas obliquely against and lengthwise of said surface; a carrier for said nozzle; mechanism whereby said nozzle is movable relatively to said carrier toward and away from, and transversely of, said surface; adjustable means for setting said nozzle to deliver said stream at a selected oblique angle, of a value not greater than 35 degrees, relatively to the plane of said surface; and mechanism for effecting continuous relative motion between said body and said carrier with said nozzle, at a uniform rate higher than that conventionally employed for severing metal by means of an oxygen jet and in a fixed direction longitudinally of said surface from adjacent one end thereof to the opposite end thereof while maintaining constant such oblique angle position of said nozzle and said stream relatively to the plane of and adjacent to said surface, to continuously remove metal from said surface and blow metal oxide and molten metal, produced by the resulting thermo-chemical action, ahead of the region of impingement of said stream against said surface; said mechanism whereby said nozzle is movable toward and away from said surface comprising link means adapted to permit said nozzle to move freely toward and away from said surface responsively to irregularities of said surface and without changing said oblique angle position of said nozzle and said stream relatively to the plane of said surface.

9. Apparatus for thermo-chemically removing a substantially uniform layer of metal from a longitudinal surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a blowpipe nozzle constructed to deliver a voluminous low-velocity stream of oxidizing gas obliquely against and lengthwise of said surface; a carrier for said nozzle; mechanism whereby said nozzle is movable relatively to said carrier toward and away from, and transversely of, said surface; adjustable means for setting said nozzle to deliver said stream at a selected oblique angle, of a value not greater than 35 degrees, relatively to the plane of said surface; and mechanism for effecting continuous relative motion between said body and said carrier with said nozzle, at a uniform rate higher than that conventionally employed for severing metal by means of an oxygen jet and in a fixed direction longitudinally of said surface from adjacent one end thereof to the opposite end thereof while maintaining constant such oblique angle position of said nozzle and said stream relatively to the plane

of and adjacent to said surface, to continuously remove metal from said surface and blow metal oxide and molten metal, produced by the resulting thermo-chemical action, ahead of the region of impingement of said stream against said surface; said mechanism whereby said nozzle is movable toward and away from said surface comprising links constructed and arranged to permit said nozzle to move freely toward and away from said surface responsively to irregularities of said surface and without changing said oblique angle position of said nozzle and stream relatively to the plane of said surface, and means cooperating with said links to retard the free movement of said nozzle toward said surface.

10. Apparatus for thermo-chemically removing a layer of metal from a longitudinal surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a blowpipe carriage movable longitudinally of said surface; a blowpipe adjustably mounted on said carriage and having a nozzle constructed to deliver a high temperature heating flame and a low-velocity voluminous oxygen stream obliquely against said surface to effect superficial metal combustion along a transverse zone of said surface; means for moving said blowpipe and nozzle relatively to said carriage toward and away from said surface; means for moving said blowpipe and nozzle relatively to said carriage and transversely of said surface; adjustable means for setting said blowpipe and nozzle to position said nozzle to deliver said stream at a selected oblique angle, of a value not greater than 35 degrees, relatively to the plane of said surface; links connected to said carriage and to said blowpipe and adapted to permit said nozzle to move freely toward and away from said surface responsively to irregularities of said surface and without changing such selected oblique angle position of said nozzle and said stream relatively to the plane of said surface; counterbalancing means cooperating with said links to yieldingly counteract the free movement of said nozzle toward said surface; and mechanism for continuously propelling said carriage and said blowpipe and nozzle at a uniform rate higher than that conventionally employed for severing metal by means of an oxygen jet and in a fixed direction longitudinally of said surface from adjacent one end thereof to the opposite end thereof, such oblique angle position of said blowpipe and stream being maintained substantially constant relatively to the plane of said surface during such propulsion to continuously maintain such combustion of superficial metal at successive zones of impingement of said stream against said surface to produce continuous thermo-chemical removal of a shallow layer of said surface throughout the entire length of the latter, remove metal from said surface and blow metal oxide and molten metal, produced by the resulting thermo-chemical action, ahead of the region of impingement of said flame and stream against said surface and onto successive portions of said surface from which metal is to be removed.

11. Apparatus for thermo-chemically removing metal from a surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a plurality of blowpipe nozzles disposed in a row, each of said nozzles being constructed to deliver a combustible heating gas jet and a jet of oxidizing gas; means, common to all of said nozzles, for simultaneously setting said nozzles at a selected oblique angle relatively to the plane of and adjacent to said surface, whereby

such jets are adapted to be concurrently applied obliquely against and lengthwise of said surface to effect superficial metal combustion along a relatively wide transverse zone of said surface; and mechanism for effecting continuous relative motion between said body and said nozzles at a uniform rate and in a direction longitudinally of said surface to maintain such combustion of superficial metal during such motion to produce continuous thermo-chemical removal of a relatively wide layer of said surface longitudinally of said body.

12. Apparatus for thermo-chemically removing metal from a surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a plurality of blowpipe nozzles disposed side by side in a row, each of said nozzles being constructed and arranged to deliver a jet of oxidizing gas obliquely against and lengthwise of said surface; means, common to all of said nozzles, for simultaneously moving said nozzles as a unit toward and away from said surface; and mechanism for effecting continuous relative motion between said body and said nozzles at a uniform rate and in a direction longitudinally of said surface.

13. Apparatus for thermo-chemically removing a relatively wide layer of metal from a surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a plurality of blowpipe nozzles disposed side by side in a row, each of said nozzles being adapted to deliver a combustible heating gas jet and a jet of oxidizing gas; adjustable means, common to all of said nozzles, for simultaneously setting said nozzles at a selected oblique angle to the plane of said surface, whereby such oxidizing jets and such heating gas jets are adapted to be concurrently applied obliquely against and lengthwise of said surface to effect superficial metal combustion along a relatively wide transverse zone of said surface; means, common to all of said nozzles, for simultaneously adjusting said nozzles as a unit toward and away from said surface; means, common to all of said nozzles, for simultaneously adjusting said nozzles as a unit transversely of the length of said surface; and mechanism for effecting continuous relative motion between said body and said nozzles at a uniform rate and in a direction longitudinally of said surface while such oblique angle position of said nozzles and jets is maintained substantially constant to maintain such superficial metal combustion during such motion and produce continuous thermo-chemical removal of a relatively wide layer of said surface longitudinally of said body.

14. Apparatus for thermo-chemically removing metal from a surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a plurality of blowpipe nozzles disposed side by side in a row, each of said nozzles being constructed and arranged to deliver a jet of oxidizing gas obliquely against and lengthwise of said surface; yieldable means normally holding said nozzles in operative position adjacent to said surface but adapted to yield responsively to irregularities of said surface to permit said nozzles to move away from said surface without changing the oblique angle positions of said nozzles and the jets thereof relatively to the plane of said surface.

15. Apparatus as claimed in claim 14, in which said yieldable means comprises link means constructed and arranged to permit said nozzles to

move toward and away from said surface in a direction perpendicular to the plane of said surface.

16. Apparatus as claimed in claim 14, in which said yieldable means comprises links constructed and arranged to permit said nozzles to move a limited distance toward and away from said surface in a direction perpendicular to the plane of said surface, and means cooperating with said links to resist the movement of said nozzles toward said surface.

17. Apparatus for thermo-chemically removing metal from a surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a plurality of blowpipe nozzles disposed side by side in a row, each of said nozzles being adapted to deliver combustible heating gas and a jet of oxidizing gas; adjustable means, common to all of said nozzles, for simultaneously setting said nozzles at a selected oblique angle to the plane of said surface, whereby such oxidizing jets and such heating gas flames are adapted to be concurrently applied obliquely against and lengthwise of said surface; means, common to all of said nozzles, for simultaneously moving said nozzles as a unit toward and away from said surface; means, common to all of said nozzles, for simultaneously moving said nozzles as a unit transversely of the length of said surface; and mechanism for effecting continuous relative motion between said body and said nozzles at a uniform rate and in a direction longitudinally of said surface while such oblique angle position of said nozzles and jets is maintained substantially constant, said means for simultaneously moving said nozzles toward and away from said surface comprising links constructed and arranged to permit said nozzles to move freely a limited distance toward and away

from said surface, and counterbalancing means cooperating with said links to yieldingly resist the free movement of said nozzles toward said surface.

18. Apparatus for thermo-chemically removing metal from a surface of a metal body, such as a steel slab or billet, such apparatus comprising the combination of a plurality of blowpipe nozzles disposed side by side in a row, each of said nozzles being constructed and arranged to deliver both a low-velocity voluminous jet of oxidizing gas and a separate high-temperature heating medium; means, common to all of said nozzles, for simultaneously setting said nozzles at a selected oblique angle to the plane of said surface, whereby such oxidizing jets and such heating media are adapted to be concurrently applied obliquely against and lengthwise of said surface; means, common to all of said nozzles, for simultaneously moving said nozzles as a unit toward and away from said surface comprising members constructed and arranged to permit said nozzles to move freely a limited distance toward and away from said surface responsively to irregularities of said surface without changing such oblique angle position of said nozzles, and means cooperating with said members to yieldingly resist the free movement of said nozzles toward said surface; means, common to all of said nozzles, for simultaneously moving said nozzles as a unit transversely of the length of said surface; and mechanism for effecting continuous relative motion between said body and said nozzles at a uniform rate and in a direction longitudinally of said surface while maintaining constant the oblique angle positions of said nozzles relatively to the plane of said surface.

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