

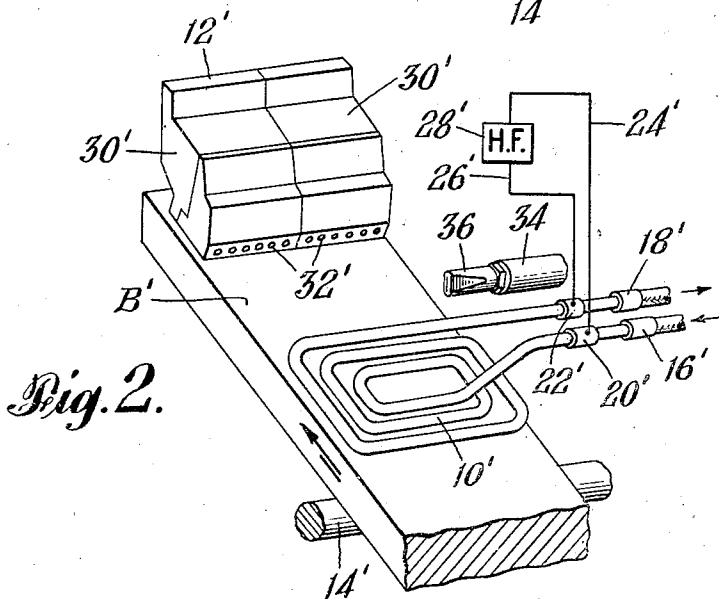
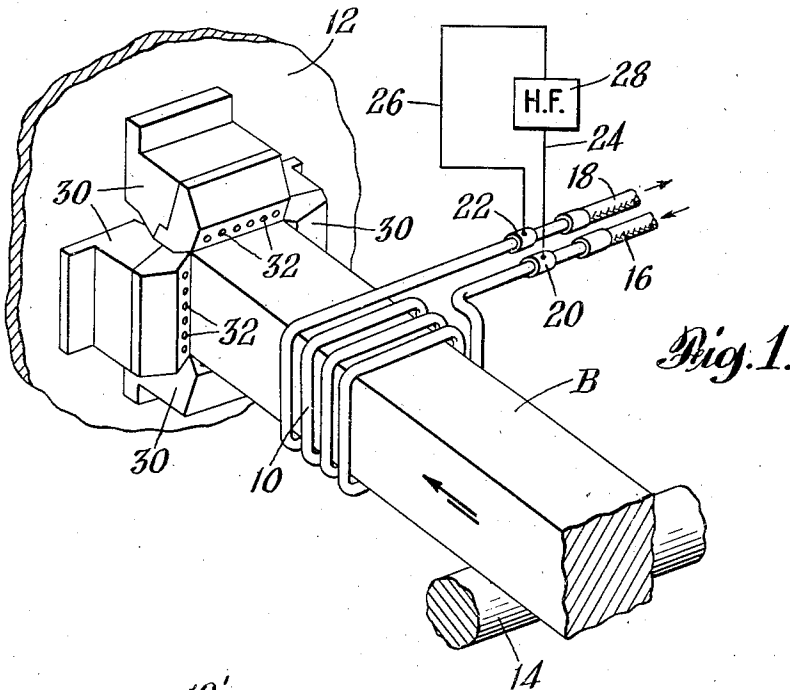
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B. R. KING

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METAL SURFACE CONDITIONING PROCESS

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INVENTOR
BARNWELL R. KING
BY *E. J. McNeir*
ATTORNEY

UNITED STATES PATENT OFFICE

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METAL SURFACE CONDITIONING PROCESS

Barnwell R. King, Flushing, N. Y., assignor to The
Linde Air Products Company, a corporation of
Ohio

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This invention relates to the art of conditioning the surfaces of metal bodies, and more particularly to an improved method of removing defects from the surfaces of metal bodies.

This application is a continuation-in-part of my application Serial No. 539,664, filed June 10, 1944, now abandoned, for "Metal surface conditioning process."

Metal bodies, particularly hot-rolled metal shapes, are conditioned in various ways to improve the surfaces. When metal bodies are heated and hot worked, they become coated with scale. Also metal bodies which are produced from cast ingots often have other surface defects such as small cracks, seams, and slag inclusions that cannot be removed by rolling and which would appear as defects in the finished products. Usually at some stage of manufacture, it is necessary that such defects be removed by surface conditioning before the metal is further worked. Several methods of conditioning are employed. For example, defective surface metal may be removed by machining, such as chipping with a chisel or milling. This is either relatively slow and tedious if done by hand, or requires very expensive and massive machinery of high first cost and high maintenance charges. For non-ferrous metals no other method is generally practiced. In steel mills, however, the combustibility of iron in oxygen permits the extensive use of oxy-acetylene desurfacing machines which remove both scale and a layer of surface metal by action of a row of oxygen jets against the surface while it is at an ignition temperature.

Although the desurfacing reaction on steel generates enough heat so that, after ignition is initially obtained, the reaction can, under certain favorable conditions, be continued along the metal surface without any auxiliary source of heat, it is, in practice, necessary that an auxiliary source of heat be supplied for the reason that the reaction with oxygen alone is relatively unstable and quite inefficient in the use of the gas. Thus it is customary to supply added heat by providing gas heating flames such as oxy-acetylene flames adjacent the oxygen jets. These flames greatly increase the efficiency of surface metal removal and stabilize the reaction. These flames are also used before the oxygen is applied initially to heat a portion of the metal to an ignition temperature. Oxygen and acetylene are generally used although sometimes a different fuel gas may be employed, but in the latter case a much larger amount of oxygen is required. Therefore,

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there is in either event, a large gas consumption expense for the heating flames.

Steel conditioning machines using oxygen and heating flames are often set into the rolling mill line. Such machine may remove from each body a thin layer containing surface defects from 1, 2 or 4 sides continuously, and the operation is performed while the metal of the body is still hot and without interrupting the rolling operation. Secondary conditioning, i. e., the removal of deeper defects, if such should be necessary, is sometimes performed by hand deseaming after the steel body has cooled down to room temperature.

The necessity of supplying gases for the pre-heating or heating flames causes considerable complication of the apparatus and involves difficulties of control and supply of the additional gas, and also the expense of maintaining the flame producing means, which maintenance would be much reduced if oxygen jets alone are employed.

Therefore, the main objects of this invention are to provide a novel and improved method of conditioning metal bodies; improved means for heating the surface of a ferrous metal body for starting and maintaining a thermo-chemical desurfacing operation on the body with oxygen; an improved method of removing surface defects from metal bodies; a process of desurfacing or deseaming in which the apparatus is simple and economical to manufacture and maintain, is efficient and effective in operation, and which effects a saving in removed metal; a process of conditioning a metal body to eliminate defects which is more efficient in use of energy and which either eliminates entirely or reduces substantially the consumption of valuable gas.

According to an embodiment of the invention particularly adapted for desurfacing steel bodies, high-frequency induction heating of the work to be desurfaced is employed in conjunction with the use of a stream of oxidizing gas containing at least a core of commercially pure oxygen in order to reduce or avoid entirely the use of preheating fuel gas, such as acetylene and the oxygen required to burn such gas. For example, a surface portion of a ferrous metal body to be desurfaced is first heated to ignition temperature with high-frequency waves from a suitable source, such as an inductor or capacitor. The induced current and resulting heat are localized, by control of the frequency, to the skin of the body which may be already at the rolling temperature of the metal, or cold. When the skin of the metal body reaches the ignition temperature with oxygen, characteristic oxidizing gas streams are applied to such

preheated skin and the surface of the latter is thermochemically removed by movement of the preheating source and oxidizing streams with respect to the body undergoing treatment.

The depth of the inductively preheated skin of the metal body may be varied or adjusted by changing the frequency of the waves induced in such skin, and the locally heated area may be predetermined with any suitable arrangement of the inductor coils or unit with respect to the surface of the skin. For example, a single loop inductor which conforms substantially to the shape of the body being treated may surround such body in order progressively to preheat a peripheral zone which is thereupon thermochemically removed by oxidizing gas streams which are directed against such preheated peripheral zone, the body being moved in the direction of the axis of the inductor loop to progressively desurface such body in a single pass. Alternatively, one or more suitable inductors may be used to preheat one or more of the faces of the body, or a portion of one face.

According to the invention a novel method of eliminating defects in the surface of ferrous metal bodies, is provided which comprises inducing in the skin of such body a high-frequency heating current to heat the surface metal to a sufficient depth to cause the surface metal at least in the zone of the defects to reach the ignition temperature with oxygen, and applying a stream of oxygen against such heated metal to remove the same thermochemically, thereby eliminating such defects. The high-frequency heating current is induced in successive portions of the metal body and the so-heated metal is progressively removed at successive surface portions by the application of the oxygen stream.

Further, according to the invention, there is provided a novel method of removing defects in the surface of a cold ferrous metal body which consists of first moving such body into the high-frequency electromagnetic field of a high-frequency induction coil disposed in close proximity to the body whereby the surface metal of the leading edge of the body is highly heated only to a very slight depth over a small transverse area of the body by high-frequency "skin effect" to a temperature above the temperature of ignition with oxygen. The body is then moved into a stream of oxidizing gas directed against the so highly-heated leading edge of the body and flowing in an oblique direction generally opposed to that in which the body is moved, so that the so highly-heated metal is oxidized and melted and scarfed from the body by the combined thermochemical action and force of the oxidizing gas stream, thereby removing such defects.

The invention includes inductively heating the surface and subsurface defects of the body to ignition temperature without raising the rest of the surface to ignition temperature, by virtue of the fact that induction heating causes the defects to heat to a higher temperature than the sound metal of the work surface; as well as inductively heating the surface metal to ignition temperature, in which case the defects are heated to a temperature higher than that of the sound metal. Thus, when oxygen scarfing is accomplished, the defects are removed, since their higher temperature assures thermochemical reaction with the oxidizing gas. This saves metal, speeds up the operation, and considerably reduces the cost of eliminating hidden and exposed surface defects in iron and steel bodies. Another advantage of the invention resides in the

fact that oxygen scarfing may be started at the very end of the leading edge of the body to be desurfaced, because the high-frequency induction heating results in a concentration of heat in the leading corner of the body as it moves through the high-frequency field. This heat concentration causes the corner to flash, so that the scarfing oxygen reacts therewith, and "bites" or starts the thermochemical reaction with the highly heated metal at such corner. Thus, the invention also solves a problem which has long vexed the industry, and avoids the need for cropping sound metal from the front end portion of the body, which was necessary in the past due to starting the scarfing action back of the front end of the body.

The above described processes may be carried out while the body is cold, but are more economically performed while the body is hot and passing from one hot working operation to another. The treatment, in addition to conditioning the body, also adds heat to the body so that a step of furnace heating the body between hot working operations which is often required can be eliminated.

In the drawing:

Fig. 1 is a fragmentary perspective view of apparatus illustrating the invention; and

Fig. 2 is a similar view of a modification of the invention.

Referring to Fig. 1, a high-frequency skin preheater 10 and an oxygen desurfacing unit 12 are arranged in rolling mill line, including a conveyor 14, to first inductively heat the skin of a ferrous metal body B to cause the leading edge and at least the defects to ignite and then thermochemically remove only the defects or scarf the whole preheated surface from the body as the latter is moved along such line by the conveyor 14.

The high-frequency skin or defect preheater 10 preferably comprises an inductor which encircles the body B, such inductor consisting of a pipe composed of electrically conductive material, such as copper or graphite, through which a cooling fluid, such as water, is circulated from a suitable source, through inlet and outlet connections 16 and 18.

The coil 10 may, if desired, be made adjustable to accommodate a body of any cross-sectional size or shape, by being formed of telescoped tubes which permit the coil to be expanded or contracted about the body.

Terminals 20 and 22 of the induction heating unit 10 are connected by conductors 24 and 26 to the output circuit of a source 28 of high-frequency alternating current, such as an electronic oscillator, for example. The power of source 28 is sufficiently high to cause the electromagnetic field of the inductor 10 to induce a current of sufficient intensity in the skin or surface layer of the body B, as the latter is moved by the conveyor therethrough, to raise the temperature of such surface until the defects only or the entire skin metal becomes at least hot enough for ignition with streams of oxygen discharged from the desurfacing unit 12.

Through the use of such high-frequency current the induction heating is confined only to the defects or to the skin or external surface layer of the body B. The depth of heating is controlled by the frequency, the amount of power induced in the surface of the body, and the rate of relative movement between the induction coil 10 and the body B. Since the body may be al-

ready at a rolling temperature, and moving at a rate of the order of 135' per minute, for example, the arrangement is such that the temperature of the skin on all four surfaces of the body B is raised to an ignition value, preferably molten, as the preheated surfaces are moved into the thermochemical reaction zone of the desurfacing unit 12.

The desurfacing unit 12 preferably comprises a plurality of heads 30, there being a head corresponding to each of the four sides of the body B. The heads 30 also may, if desired, be made so that they may be adjusted to accommodate a body B of any cross-sectional shape or size. Each head 30 includes a plurality of desurfacing nozzles 32, each of which is provided with an orifice for discharging a characteristic stream of commercially pure oxygen at an acute angle against the adjacent surface or side of the body as the latter is moved through the unit 12. Oxygen at a suitable pressure is supplied to each of the nozzles 32 in use during the desurfacing operation.

In operation, the body B is moved by the conveyor 14 first through the alternating electromagnetic field of high-frequency and high power, within the induction heater 10, inducing heat in the surface metal of the body until it reaches at least the ignition temperature, and then through the zone of the inclined streams of oxidizing gas discharged by the nozzles 32 of the heads 30 of the desurfacing unit 12, which impinge against the work surface at an acute angle and thermochemically remove the inductively heated surface metal from the body B. In this way surface defects are entirely removed from all sides of the ferrous metal body B.

As the leading end of the body B passes through the coil 10, the four leading corners of the body ignite, thus assuring starting of the thermochemical reaction with the oxidizing gas streams discharged by the nozzles 32. As the body proceeds through the coil, the surface and subsurface defects also ignite. Thus the thickness of the removed skin may be reduced to a minimum, or alternatively only the defects may be removed, as desired. In either case, however, the high-frequency induction heating causes higher heating of the defects, assuring their elimination by the oxidizing streams, since the higher the temperature of the work, the better the reaction with oxygen. The oxidizing gas stream may be either commercially pure oxygen alone, or a core of oxygen and an adjacent flame composed of oxygen and fuel gas.

Referring to Fig. 2, there is illustrated a modification for removing surface defects from the top only of a ferrous metal slab B' as the latter is advanced by a conveyor 14'. The slab B', which may be already at a rolling temperature, is moved by the conveyor directly under the induction heating unit 10' in the form of a pancake coil comprising a plurality of turns of copper or graphite tubing having terminal portions 20' and 22' provided with cooling fluid inlet and outlet connections 16' and 18', such terminal portions being also connected in the output circuit of a high-frequency power source 28' by conductors 24' and 26'.

The coil 10' may be provided with a suitable core, not shown, for the purpose of concentrating the magnetic flux, and the heating current thereby induced in the slab B', so that intense heat is generated and concentrated in a limited portion of the upper surface of the slab B',

causing at least the defects to ignite, as the body is moved toward the desurfacing unit 12' consisting of a pair of heads 30', including oxygen discharging nozzles 32'. In this modification there is provided a water supply pipe 34 which terminates in a nozzle 36 for discharging a flat stream of water above and across the top surface of the slab B' and in edgewise relation thereto, to continuously deflect and remove slag resulting from the desurfacing operation, the water stream discharged by the nozzle 36 being positioned so as to protect the induction coil 10' from the thermochemical reaction and from the products of combustion and slag. In this manner the coil 10' can be positioned close to the nozzle heads 30'.

In operation, the slab B' is moved by the conveyor 14' in the electromagnetic field of the high-frequency coil 10', inducing current in the surface of the slab which heats the entire skin or only the defects for ignition with oxygen. Streams of oxygen discharged by the nozzles 32' of the desurfacing unit 12' thermochemically combine with and remove the metal at ignition temperature from the surface as the conveyor 14' continues to advance the slab B' under the unit 12'. The slag resulting from the thermochemical desurfacing operation is projected forwardly of the unit 12' along the surface of the slab toward the coil 10'. During this operation the stream of water discharged by the nozzle 36 continuously removes slag from such surface and protects the coil 10' from the intense heat and from such slag.

According to the invention, a surface layer of predetermined thickness, depending upon the frequency selected, is heated to the desired temperature by means of a high-frequency source of electricity. However, the invention also includes removing all or only the defective portion of such heated layer while it is molten or soft thermochemically with oxidizing gas such as an oxygen stream (as shown in Figs. 1 and 2). Since the thickness of the surface layer or skin which is heated by induction is a function of the frequency of the source of electricity, automatic control of the depth of the surface layer of metal which is removed from the body is accomplished by increasing or decreasing such frequency.

In desurfacing with oxygen, according to the invention, it will be understood that an alternating current of high-frequency may be induced in a surface zone of a steel body, for example, to heat the metal of such zone to an ignition temperature for thermochemical reaction with oxygen. A stream of oxygen is then applied against the heated metal in such zone at an acute angle to the surface of the body. Successive zones are similarly heated along a predetermined path to be deseamed on the surface of the body, and the stream of oxygen is advanced along such path and directed obliquely against such heated zones, so that the heated metal is progressively removed.

In addition to controlling the depth of a conditioning operation, a distinct advantage of the invention arises by virtue of the fact that a defect in the surface of a metal body is caused to heat more readily than the sound metal because of the skin-effect of the high-frequency current induced in the metal body, the current being urged to flow in a surface layer of predetermined depth. Also when desurfacing with oxygen, the resistance of the defect to the flow of induced current causes the latter to attain a higher temperature and thereafter to ignite and react or

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burn, more easily than the solid surface metal when the oxygen is applied. Thus, when a stream of oxygen is subsequently applied to the inductively preheated surface metal, the glowing defects, being hotter than the surrounding metal, are removed more completely by thermochemical reaction with the oxygen. A saving of metal is effected because the entire surface need not be removed to the full depth of the deepest defects. The oxygen stream removes metal to a greater depth wherever the temperature of the metal is higher, thus only a very thin layer or no layer at all of sound metal need be removed while the defective metal in the region of the defects is, in either case, automatically removed.

My copending application Serial No. 738,957, filed April 2, 1947, which is a division of my application Serial No. 539,664, contains generic claims as well as claims covering another species of the invention.

What is claimed is:

1. The method of eliminating defects in the surface of a ferrous metal body which comprises inducing in the skin of such body a high-frequency heating current to heat the surface metal to a sufficient depth to cause the surface metal at least in the zone of the defects to reach the ignition temperature with oxygen, and applying a stream of oxygen against such heated metal to

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remove the same thermochemically, thereby eliminating such defects.

2. The method as claimed in claim 1 which comprises inducing such high-frequency heating current progressively in successive portions of the metal body and progressively removing such heated metal at successive surface portions by the application of such stream of oxygen.

BARNWELL R. KING.

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