

May 12, 1942.

E. W. DECK

2,282,397

METHOD OF AND APPARATUS FOR TREATING DEFECTIVE SURFACES OF METAL BODIES

Filed March 3, 1939

4 Sheets-Sheet 1

Fig. 1.

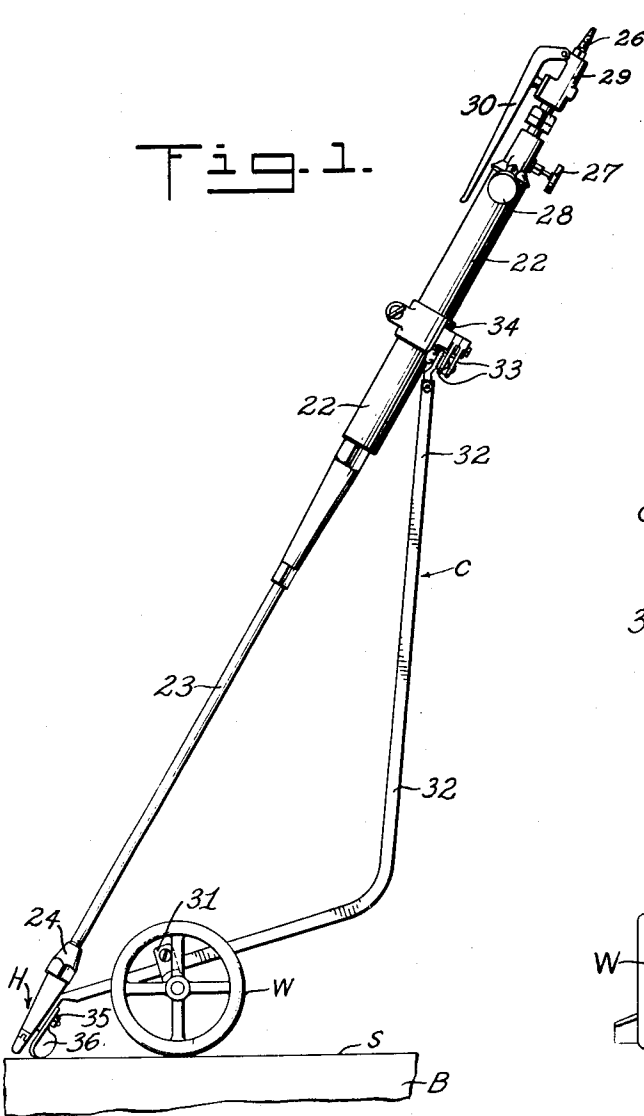


Fig. 2.

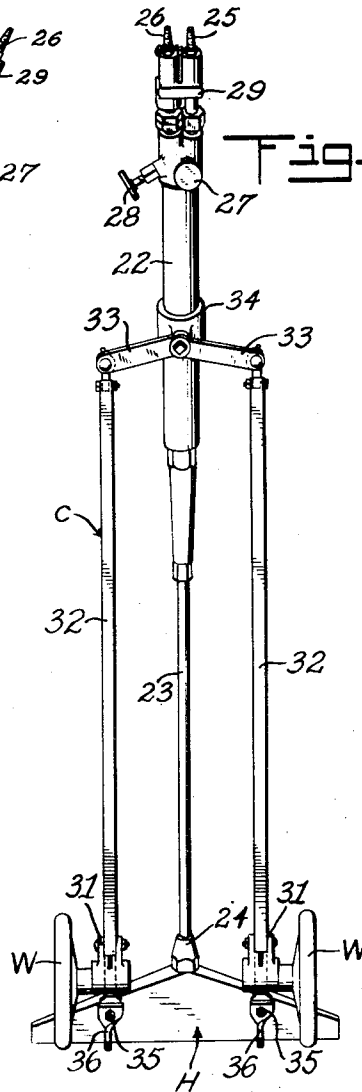
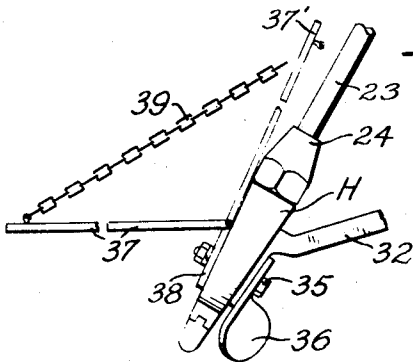


Fig. 3.



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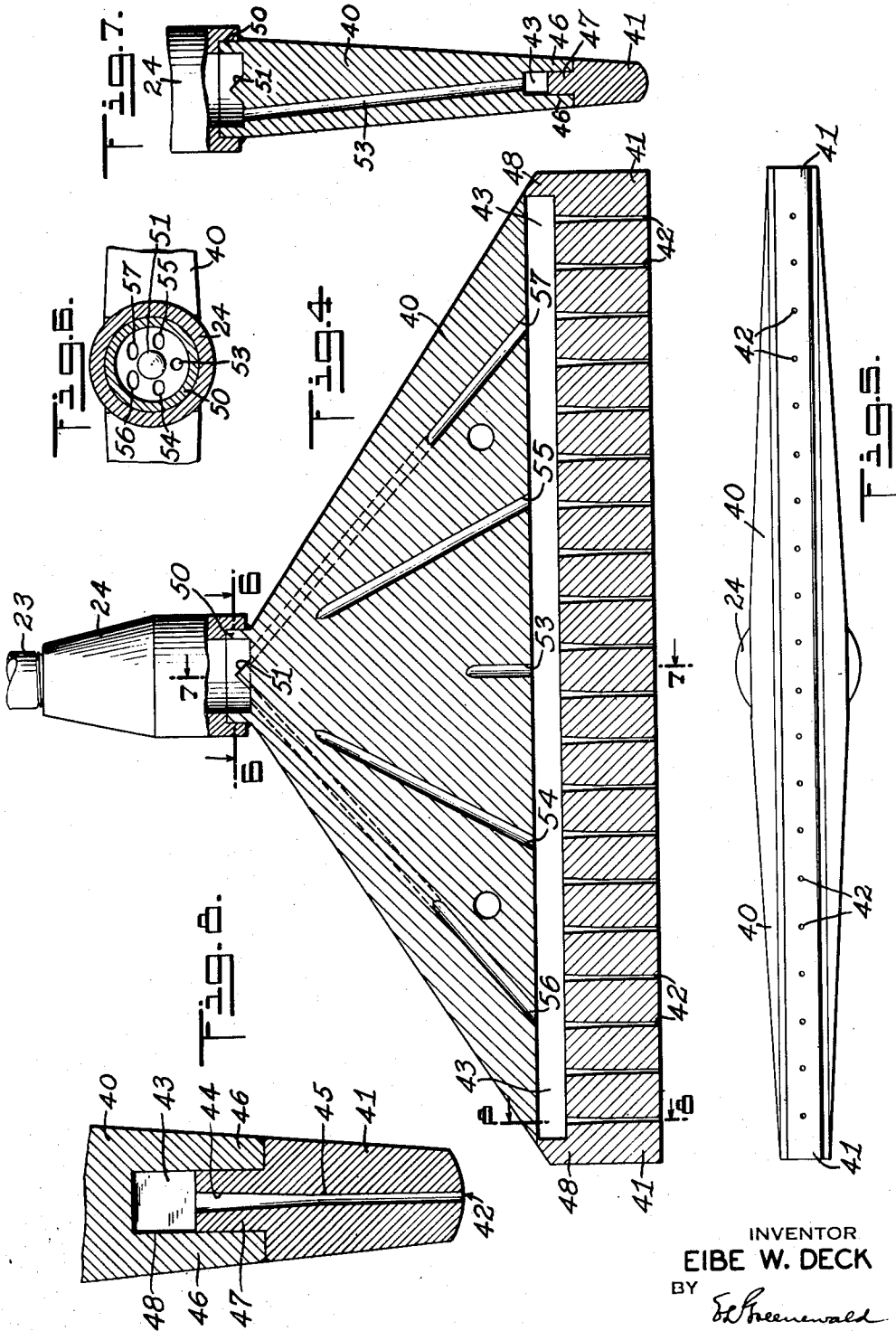
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4 Sheets-Sheet 2



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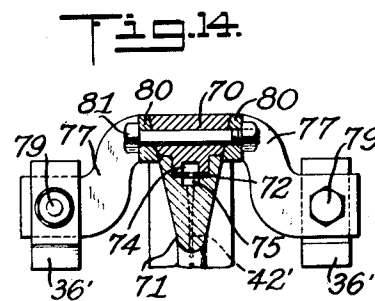
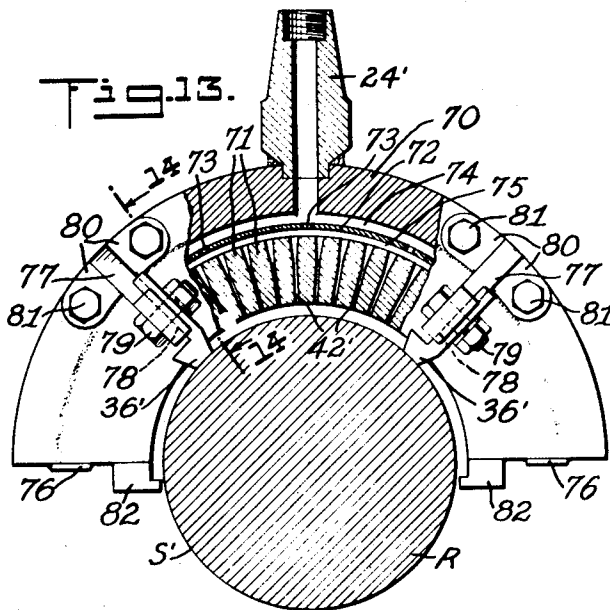
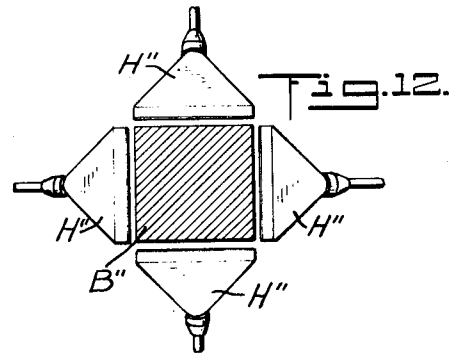
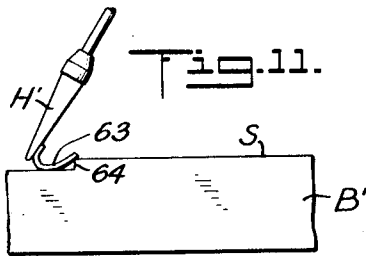
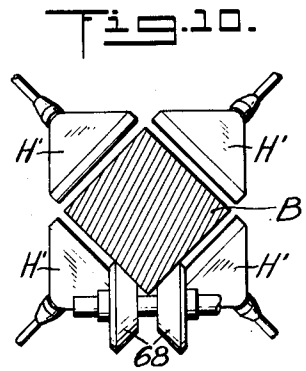
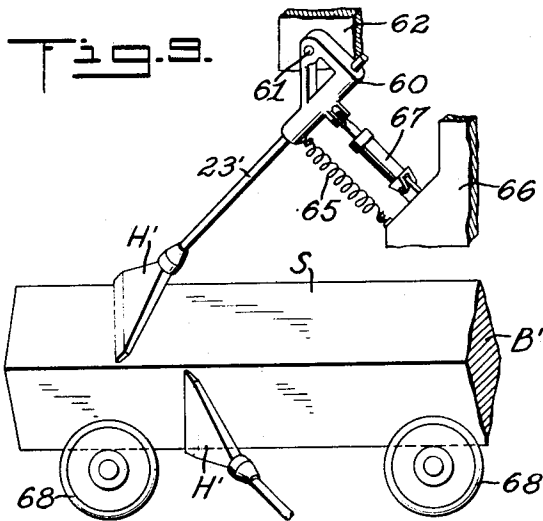
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Fig. 15.

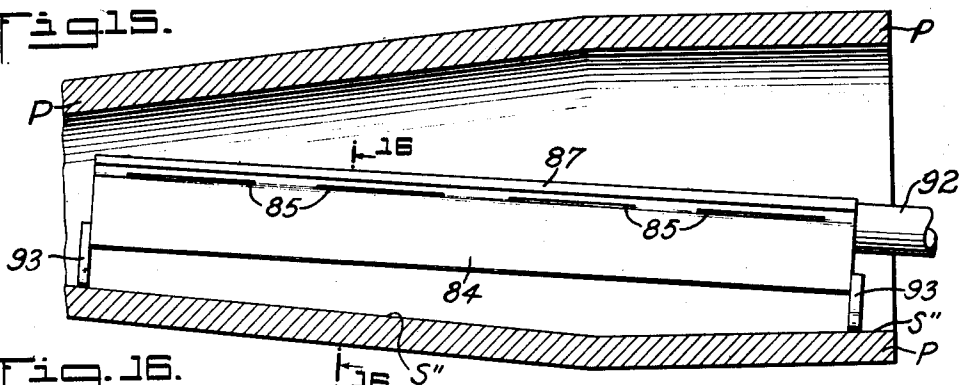


Fig. 16.

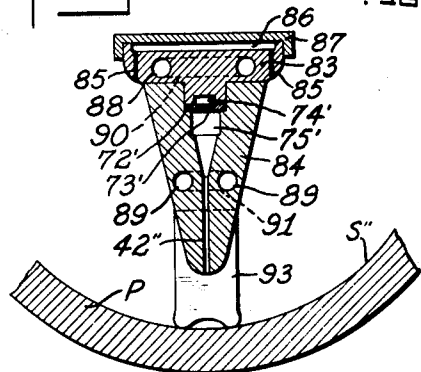


Fig. 17.

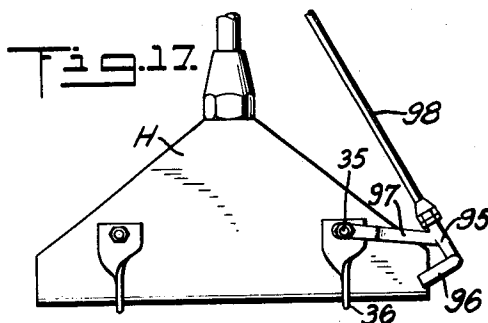


Fig. 18.

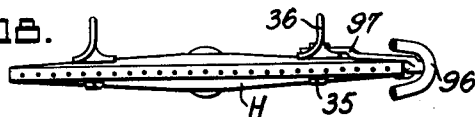


Fig. 19.

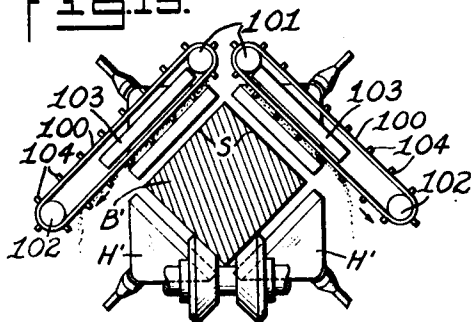
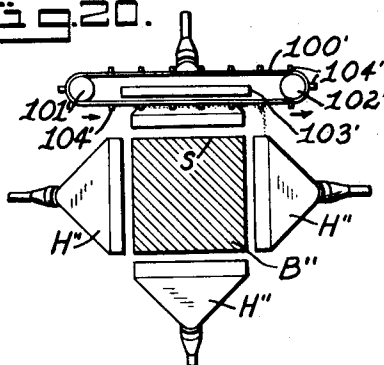


Fig. 20.



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METHOD OF AND APPARATUS FOR TREATING DEFECTIVE SURFACES OF METAL BODIES

Eibe W. Deck, Plainfield, N. J., assignor to Oxweld Acetylene Company, a corporation of West Virginia

Application March 3, 1939, Serial No. 259,495

20 Claims. (Cl. 29—81)

This invention relates to the treatment of defective surfaces of metal bodies, and more particularly to a method of and apparatus for removing scale from a surface of a ferrous metal body, such as a bloom, billet, slab, or the like. The principles of this invention are particularly applicable to the treatment of blooms or billets to remove surface scale therefrom prior to inspection, but may be applied in other instances and for other purposes.

Blooms, billets, and slabs are formed from ingots by a hot rolling process which is carried out in a rolling mill, the cross-sectional area of the bloom or ingot being reduced during rolling. Prior to rolling, an ingot is placed in a soaking pit to be heated to a relatively high temperature, such as about 2200° F. for ordinary steel ingots. While in the soaking pit, and after its removal therefrom, the outer surfaces of the ingot come into contact with air, and scale forms on these surfaces from oxidation due to reaction with the oxygen present in air. The scale which forms on a surface at a rolling temperature, such as about 2200° F. or above, is a grayish scale; while the scale which forms on a surface at a temperature of around 1600° F. is a black scale. Black scale is much more difficult to remove than gray scale, but, fortunately, the greater proportion of scale normally present on the surface of a bloom or billet is the more easily removable gray scale.

During passage of a bloom or ingot through the last pass in a rolling mill, scale is pressed into the upper and lower surfaces of the bloom or ingot by rolls contacting the same to form what is termed "flake scale," while scale on the sides of the bloom or ingot is compressed from above and below to form what is termed "feather scale." Furthermore, new scale will tend to form as long as the surface is at a relatively high temperature, but scale already present on a surface will tend to retard the formation of new scale. After passage through a rolling mill, the scale present on the surface of a bloom or billet is normally a relatively heavy layer of gray flake scale and also feather scale, or, in some instances, a thinner layer of newly formed black scale.

Before the bloom or billet undergoes further processing, it is necessary to inspect the same so that defects formed during pouring of the ingot or during rolling may be removed. Defects formed during pouring of the steel into a mold to form the ingot may consist of seams, cracks, scabs, slag inclusions, blow holes, surface gas pockets, etc., while defects formed during rolling may consist of rags caused by heavy bites during

rolling, scoring, etc. Needless to say, it often is necessary to remove the scale in order to ascertain whether or not such defects are present, and the bloom or billet is also allowed to cool to permit this inspection.

Heretofore, scale has been removed by placing the cooled bloom or billet in an acid bath, a chemical reaction between the acid and the scale, and more particularly between the acid and the ferrous base metal underneath the scale, causing the scale to become loosened. Such a procedure not only consumes a considerable amount of time and necessitates special handling, thus becoming a "bottleneck" in a production process, but also does not give uniform results, i. e. if the bloom or billet is left in the acid bath a sufficient time to loosen the most tenacious scale, the less tenacious scale will drop off, and the surface thus exposed will be deeply etched; while if the bloom or billet is left in the acid bath for only a time sufficient to cause the less tenacious scale to be loosened, then the more tenacious scale can not be effectively removed. In addition, the acid tends to cause a hydrogen embrittlement of the steel, probably caused by infiltration into the steel of atomic hydrogen released by reaction with the acid, and the formation of molecular hydrogen within the steel by the combination of atomic hydrogen. Upon subsequent rolling, forging, or working, steel will become brittle wherever the molecular hydrogen is or has been present.

It has been proposed recently to remove the scale by heating the scale so as to cause a differential expansion between the scale and the substantially unheated body underneath by utilizing a relatively wide heating flame extending across the width of the surface and having a velocity sufficient to blow away loosened scale. The heating flame so used was formed by mixtures of air and a combustible gas, but I have found that such a flame has an insufficient heating effect to effectively remove scale. Furthermore, I have found that merely causing a differential expansion between the scale and the body underneath is often insufficient to remove the scale, and I have also found that the best results are obtained when the scale is heated at a sufficiently rapid rate so that there will be a differential expansion between the top and the bottom of the scale itself. This latter differential expansion not only causes the scale to become loosened from the bloom or billet, but also causes the scale to pop off in large particles or chunks. In addition, to render the operation effective for commercial

purposes, the operation must proceed at a relatively rapid rate. To achieve these desired results, I have found that it is necessary to utilize heating flames having a sufficient velocity and temperature to heat the outer surface of the scale quite rapidly to an elevated temperature.

Among the objects of this invention are to provide a method of removing scale in which the scale is heated at a sufficiently rapid rate to effect not only a differential expansion between the scale and the body of metal beneath, but also to effect a differential expansion between the top and bottom of the scale itself; to provide a method of removing scale in which the operation will proceed sufficiently rapidly to be effective for commercial purposes; to provide a method in which the scale may be removed effectively and economically; and to provide apparatus which is particularly adapted to carry out the method of this invention. Other objects and novel features will become apparent from the following description and accompanying drawings in which:

Fig. 1 is a side view of manually propelled apparatus constructed in accordance with this invention, and in operative position for removing scale from the surface of a ferrous metal body, such as a bloom or billet;

Fig. 2 is a rear view of the apparatus of Fig. 1;

Fig. 3 is a fragmentary side view of the apparatus of Fig. 1 equipped with a baffle for melting ice and snow;

Fig. 4 is a longitudinal sectional view of a heating head utilized in the apparatus of Figs. 1 and 2;

Fig. 5 is a bottom view of the heating head;

Fig. 6 is a horizontal sectional view taken along line 6—6 of Fig. 4;

Fig. 7 is a vertical sectional view taken along line 7—7 of Fig. 4;

Fig. 8 is an enlarged vertical sectional view taken along line 8—8 of Fig. 4;

Fig. 9 is a side view of mechanically operated apparatus for removing scale simultaneously from each of the four sides of a bloom or billet;

Fig. 10 is a partial end view of the apparatus of Fig. 9;

Fig. 11 is an oblique side view of one of the heating heads of the apparatus of Fig. 9 and a portion of the bloom or billet;

Fig. 12 is an end elevation of apparatus similar to that of Fig. 9, but operating with the bloom or billet in a different position;

Fig. 13 is an end view, partly in section, of apparatus in operative position for removing scale from the outer surface of a round or circular metal body;

Fig. 14 is an oblique sectional view taken along line 14—14 of Fig. 13;

Fig. 15 is a side view of apparatus in operative position for removing scale from the interior of a tubular metal body, the latter being shown in section;

Fig. 16 is a vertical sectional view taken along line 16—16 of Fig. 15;

Fig. 17 is a rear view of the heating head of the apparatus of Figs. 1 and 2, equipped with means for directing air jets against loosened scale;

Fig. 18 is a bottom view of the heating head and attendant apparatus shown in Fig. 17;

Fig. 19 is a partial end view similar to Fig. 9, of the apparatus of Figs. 9 and 10 equipped with magnetic means for carrying away loosened scale; and

Fig. 20 is an end view similar to Fig. 12, of the apparatus of Fig. 12 equipped with magnetic means for carrying away loosened scale.

In accordance with this invention, a flame velocity in excess of 600 feet per second is utilized. (A flame velocity in excess of 600 feet per second as used herein refers to the average velocity across the port or orifice from which issues the jet of combustible mixture to form the heating flame, since the actual velocity may differ in various portions of the jet.) Such a velocity has been found to be desirable in order to provide a sufficient rapidity of heat transfer between the heating flame and the outer surface of the scale. Also, further to increase the heating effect, the constituents of the combustible mixture which forms the flame are preferably substantially pure oxygen and acetylene, the latter being a fuel gas having a relatively high heating value. In order to provide the desired high velocity, it is desirable to utilize small individual heating flames or jets, which may be formed by passing the combustible mixture through a plurality of relatively long passages or outlets of small diameter, the outlets having a converging approach section and a relatively long discharge section, preferably about 12 to 15 times the diameter thereof. A plurality of these individual heating jets, spaced closely together in a single row across the width of the surface, are directed against successive longitudinal portions of the scale. Finally, and further to increase the velocity and temperature of the heating jets, the combustible mixture is preheated before its passage through the relatively long discharge passages, in a manner which will hereinafter appear.

Manually propelled apparatus, constructed in accordance with the principles of this invention, may comprise a carriage C, as in Figs. 1 and 2, upon which a heating head H is mounted. A plurality of high velocity, high temperature heating flames are directed against a surface S of a billet B from the lower face of heating head H, and carriage C is provided with wheels W which roll along the surface S, permitting the heating flames to be directed against successive longitudinal portions of the surface. The carriage may be pulled or pushed along the surface, but is preferably pulled, since a better view of the effect of the operation may thus be had by the operator. However, in treating a plurality of blooms or billets stored or stacked side by side, it may be desirable to pull the carriage along the top surface of one bloom, and push it back along the top surface of the next adjacent bloom, thereby saving considerable time.

A combustible mixture of gases, such as oxygen and acetylene, is supplied to head H from a blow-pipe 22 by a tube 23, which is connected to head H by a coupling 24. The blow-pipe 22 also serves as a handle for the carriage, and oxygen and acetylene are supplied to the blowpipe by suitable hoses attached to nipples 25 and 26, and connected to suitable sources of supply of oxygen and acetylene, respectively. The blowpipe is provided with a suitable mixer for forming the combustible mixture, and the flow of oxygen and acetylene therethrough controlled by valves 27 and 28, respectively. In addition, a quick-acting shut-off valve 29 controlled by a lever 30 is installed between nipples 25, 26 and valves 27, 28 so that the adjustment of valves 27 and 28 need not be altered when the supply of oxygen and acetylene to head H is shut off in moving the

carriage from a surface from which scale has been removed to another surface to be treated.

The wheels W are adjustably mounted, by means of clamps 31, on each of two tubular frame members or tubes 32. Tubes 32 are attached at their upper ends to links 33, pivoted on a clamp 34 secured to blowpipe 22; and tubes 32 are attached at their lower ends to head H by bolts 35. Bolts 35 also serve to secure in position a pair of skids 36, which are formed of material which remains hard at relatively high temperatures, or are provided with a deposit of such material on the lower edges which contact surface S. An alloy of cobalt, chromium, and tungsten is suitable for the latter purpose. Skids 36 prevent the lower face of head H from contacting heated scale and also maintain the correct spacing of head H with respect to surface S. For most instances, the head H is preferably spaced from the surface S at such a distance that the tips of the inner cones of the heating flames will be about $\frac{1}{8}$ in. from the scale.

The apparatus of Figs. 1 and 2 is particularly adapted to be used at places in which a number of blooms or billets are stored, and since blooms or billets are often stored outside, ice and snow collect on them during cold weather. In order to maintain a desired speed of traverse, it is necessary to remove such ice and snow, which can be done effectively by melting the same. For this purpose, a suitable baffle of asbestos or similar heat-resisting material may be utilized. As in Fig. 3, a baffle 37 may be secured to head H and extend forwardly so as to reflect heat and direct heated gases onto the ice or snow ahead of the portion of the surface from which scale is at the moment being removed. The snow removal baffle, when positioned as shown in Fig. 3, operates most effectively when the carriage is pulled along the surface. Baffle 37 may be pivoted at the top of a mounting strip 38 secured to head H so that the baffle may be moved upwardly in dotted position 37' when not in use. A chain 39 secured at one end to baffle 37 and at the other end to tube 23 by suitable means (not shown) may be provided to hold baffle 37 in the desired operating position when the baffle is swung downwardly.

The head H, as in Figs. 1 and 4-8, comprises a relatively large, solid upper block 40 in which combustible mixture distributing passages are drilled, and a lower block or strip 41 in which relatively long passages or outlets 42 are drilled, a distributing chamber 43 being formed between the upper and lower blocks and the two blocks being integrally secured in a suitable manner, such as by welding or silver soldering. The upper block 40 is solid in order that heat will be conducted therethrough to preheat the combustible mixture as it passes through the distributing passages, and the upper and lower blocks are made of copper, or other material having a high coefficient of heat transmission, to permit the conduction of a maximum amount of heat.

Outlets 42, as shown more clearly in Fig. 8, have a relatively long, gradually tapering approach section 44 and a relatively long, cylindrical discharge section 45, which preferably has a length of substantially 12 to 15 times its diameter. Outlets 42 are drilled in strip 41 before the strip is secured to the upper block, since the gradually tapering approach section may be formed accurately by drilling or machining from above. Furthermore, any burrs or the like resulting from drilling may be removed, thus insur-

ing a smooth, even flow of the combustible mixture into each outlet. This particular feature can be advantageously employed in the construction not only of apparatus for removing scale, but also in the construction of any blowpipe which is to produce a plurality of heating flames.

By reason of the long tapering approach section, and the relatively long discharge section, the jets discharged from outlets 42 will acquire a high velocity without turbulence, and this velocity will further be increased by preheating of the combustible mixture effected in its passage through upper block 40. In addition, by utilizing a ratio of oxygen to acetylene in the combustible mixture of 1.5 to 1 or 2 to 1, rather than the neutral or molar ratio of 1 to 1, the temperature of the flames may be further increased. The cooperation of each of the above factors will assist in achieving the rapid heating necessary for the effective removal of scale.

The distributing chamber 43 is formed between the upper and lower blocks by lips 46 of the upper block, which extend over a projection or tongue 47 of the lower block, tongue 47 fitting within lips 46. The ends of the distributing chamber are closed by ears 48 at either end of lower block or strip 41.

An inlet 50 of upper block 40 is secured to coupling 24 in a suitable manner, such as by brazing or silver soldering, and a gas distributing cone 51 effects an equal distribution of the combustible mixture to each of five distributing passages, the inlets of which are disposed radially about cone 51. As in Figs. 4, 6, and 7, a distributing passage 53 extends centrally through upper block 40, and the outlet of this distributing passage is so located that the combustible mixture impinges upon the upper surface of strip 41 between two outlets 42. Distributing passages 54 and 55 are inclined outwardly on either side of passage 53, and similarly direct the combustible mixture against the upper surface of strip 41 at points spaced between two outlets 42, as also do passages 56 and 57, which are further inclined and on either side of passages 54 and 55, respectively. Each of the distributing passages supplies the combustible mixture principally to a small equal number of outlets 42, in this instance four, which further insures a more equal distribution of gas. During passage through distributing passages 53, 54, 55, 56, and 57, the combustible mixture will be preheated, as previously mentioned.

While the manually propelled apparatus is conveniently used in many instances, considerable time can be saved by mechanizing the apparatus, and also by removing scale from all four sides of a bloom or billet simultaneously. For this purpose, heating heads similar to head H of the manually propelled apparatus may be suitably supported to direct a plurality of high temperature heating flames against each of the four sides of the bloom or billet, and the bloom or billet passed through the space between the heating heads in a diagonal position, as in Figs. 9 and 10, or in a flat position, as in Fig. 12.

Heating heads H' of Figs. 9 and 10 and heating heads H'' of Fig. 12 are substantially identical with head H of the apparatus of Fig. 1, and are supported in any suitable manner in operative relation with respect to the surface to be treated. One suitable type of support, as in Fig. 9, includes a hinge 60 in which tube 23' is rotatably secured to support head H', hinge 60 being pivoted on a pin 61 secured to a stationary

supporting member 62. By pivoting about pin 61, head H' may move toward or away from surface S of a bloom or billet B', from which scale is being removed, and by rotating in hinge 60, tube 23' will permit head H' to follow any twist or warp in the surface. A skid 63, as in Fig. 11, is attached to head H' to insure proper spacing between head H' and surface S, and also to cause head H' to follow configurations or irregularities of the surface, such as a notch 64. Material which remains hard at elevated temperatures is deposited upon the lower surface of skid 63, or the surface which contacts the bloom or billet, or the skid may be made of such material, as in the case of skids 36 of the apparatus of Figs. 1 and 2.

A spring 65 is attached at one end to hinge 60 and at the other end to a stationary supporting member 66, the tension of spring 65 tending to keep skid 63 in contact with surface S. A dash pot 67, attached at one end to hinge 60 and at the other end to stationary support 66, prevents head H' from suddenly jumping away from surface S as skid 63 passes over more pronounced irregularities, thereby smoothing out movements of head H' toward and away from the surface. Thus, spring 65 and dash-pot 67 cooperate to keep skid 63 in contact with the surface and to maintain the proper spacing, or relative position, of head H' with respect to surface S.

The blooms or billets are conveyed between the heads by rolls 68, and each of heads H' or H'' may be supported in the same manner as that illustrated, but it will be understood that other types of supports may be utilized, or the bloom or billet maintained stationary and heads H' or H'' moved relatively thereto by being mounted on a suitable carriage or similar moving support. However, it is desirable that two of the heads be positioned ahead of the remaining two heads, as in Fig. 9, so that one head will not interfere with the operation of an adjacent head, more particularly with respect to possible momentary disruption of the application of heat by dislodged or flying scale.

Heads H' and H'' correspond in width to the surfaces from which scale is being removed, but in case scale is to be removed from surfaces of varying widths, sets of similar heads corresponding to each width may be constructed. However, it may prove more desirable to construct similar heads of appropriate widths so that a single head may be used for the surfaces having the smallest width, and two or more heads may be bolted or suitably supported side by side for surfaces having greater widths. The widths selected for such heads will, of course, depend upon the variety of sizes of metal bodies which are to be treated at any particular plant or location, but the net result will be that a lesser total number of heads will be sufficient for a greater number of different surface widths.

The heating head of the apparatus of Figs. 1 and 2 may also be employed in removing scale from the surface of a cylinder, round bar, or the outer surface of a tube. In such cases, the head may be supported in a relatively stationary position with the row of heating flames directed onto a longitudinal element of the surface while the cylinder or round bar is rotated relatively thereto so that scale will be removed from the surface over a circumferential portion having a width substantially that of the heating head. However, the heating head may be so constructed as to conform to a part of the circumference of the

cylinder, etc., or may be ring-shaped so as to conform in shape to the entire circumference.

A suitable heating head which will direct heating flames around approximately 180° of the circumference of the surface of a cylinder or round bar, or the outer surface of a tube, is illustrated in Figs. 13 and 14. Such a head includes a semi-circular outer block 70, and a semi-circular inner block 71, integrally secured together in a suitable manner, such as by welding, brazing, or silver soldering. Outlets 42', similar to outlets 42 of heating head H, are drilled in the inner block, and direct heating flames against surface S' of a cylinder or round R.

The inner block 71 is provided with ears which cooperate with a projection on the outer block to form a space therebetween, substantially in the same manner as in head H. A semi-circular baffle plate or insert 72 is held securely between the outer and inner blocks, and insert 72 is provided with a series of holes or orifices 73 for distributing the combustible mixture to outlets 42'. The combustible mixture passes through an inlet connection 24' to an upper channel 74 formed between the outer block and insert 72, and thence through orifices 73 into a distributing channel 75 formed between insert 72 and the inner block. Plates 76, which close the ends of passages 74 and 75, are attached to the outer and inner blocks in a suitable manner, such as by welding or silver soldering. Each orifice 73 is preferably so positioned that the combustible mixture will not pass directly into any of the outlets 42', and each orifice also preferably supplies an equal number of outlets, in this instance four. In this manner, an equal distribution of gas to each outlet 42' will be effected.

For maintaining the heating head at the desired distance from surface S', a pair of skids 36' is attached to the heating head on either side thereof by skid-supporting arms 77. Skid-supporting arms 77 are provided with grooves 78, in which skids 36' are secured by bolts 79, and arms 77 are also provided with flanges 80 which are secured to outer block 72 by bolts 81. Skids 36' are formed of, or are provided with a deposit of, material which remains hard at relatively high temperatures, in the same manner as skids 36 of Figs. 1 and 2.

Protective skids or ears 82 are secured to inner block 71 at the inner corners thereof in a suitable manner, such as by welding. It is not intended that these protective skids should contact surface S' during operation, but that they should prevent possible damage to the heating head.

During the removal of scale from surface S', the heating head of Figs. 13 and 14 may be supported in any suitable manner, such as that employed in supporting heating heads H' of Figs. 9 and 10, thereby remaining relatively stationary. The cylinder R is moved longitudinally, so that scale will be removed from the upper half of the surface, the cylinder then being turned through 180°, and scale removed from the remaining half of the surface. While scale is thus effectively removed from the surface of the cylinder, in some instances it may be desired to remove the scale from the entire surface in a single operation. For this purpose, the heating heads of Figs. 13 and 14 may be constructed so as to encircle cylinder R. However, scale removed from the upper half of the surface tends to slide around the surface and impair the operation of the heating flames directed against the scale on the lower half of the surface, and it

may therefore prove desirable to utilize two heating heads, each head directing heating flames against one half, or a slightly greater portion, of the circumference of the surface.

These two heating heads may be similar to, or identical with, the heating head of Figs. 13 and 14, and one of the heads may be positioned a slight distance away from the other head to form a staggered arrangement similar to that of Fig. 9. However, a more effective arrangement may consist of both heads operating upon the upper half of the surface, but spaced a suitable distance apart, such as several feet. In utilizing this latter arrangement, the cylinder or round bar is not only moved longitudinally, but is also revolved or rotated continuously at a rate sufficient to present one-half of the surface to the first head and the remaining half of the surface to the other head, whereby each head removes scale from a helical or spiral path around the surface. An advantage of this method of operation lies in the fact that scale, after removal, will slide off the surface during rotation, the tendency for scale to pile up thereby being obviated.

During such operations, the heating heads may be mounted on a lathe carriage, and cylinder R supported for rotation between the centers of the lathe; or cylinder R may be supported for rotation between centers on a movable carriage and the heating heads supported in a stationary position. Again, cylinder R may be moved longitudinally and rotated by mechanism similar to that used in drawing tubes from round bars or billets, i. e., by rollers engaging the outer surface.

For removing scale from the interior of a tubular metal body, a heating head may be employed in which the outlets are drilled in an outer block, the relative positions of the parts of the head of Figs. 13 and 14 being similarly transposed. Such a head may be moved longitudinally through the tube, or the tube moved relatively thereto, to remove scale from successive halves of the inner surface during two passes. Again, the head may be ring-shaped and scale removed from the entire surface in a single longitudinal pass, or two or more heads may be utilized and a combination of longitudinal and rotational movement utilized whereby each head removes scale from a helical or spiral path about the inner surface.

Moreover, an elongated head adapted to direct a row of heating flames against a longitudinal element of the inner surface may be employed, a relative rotational movement between the head and the tube being employed so that scale will be removed from a circumferential portion of the inner surface having a width substantially equal to the length of the heating head. This procedure is particularly applicable to the removal of scale from the upset ends of drill pipe, since the same heating head may be utilized in removing scale from both the inner and outer surfaces of an upset end, as will be more clearly pointed out later.

Drill pipe is usually made of seamless drawn tubing, but to provide an extra thickness of metal at the ends so that the strength of the drill pipe will not be reduced by threads, the ends are upset by heating and forging. While little or no scale is normally present on seamless drawn tubing, scale which forms during the heating and forging produces thread-machining difficulties and is also otherwise objectionable.

For removing the scale from upset ends of

drill pipe, apparatus similar in principle to the apparatus previously described may be employed. However, because of the closed space in the interior of the tube, it is desirable to provide a supply of additional oxygen for secondary combustion of the heating flames when scale is being removed from the inner surface. This additional oxygen may be supplied by air jets which may also be so directed as to prevent loosened scale from piling up under the heating jets, although jets of oxygen may be utilized. Furthermore, in this closed space, the products of combustion envelop the heating head, and tend to cause the head to become overheated. When the head becomes overheated, brazed or silver soldered joints will become loose, and portions of the head, such as at the orifices of the heating jet outlets, tend to melt, thereby causing the head to become disfigured and outlets to be plugged. In addition, when the head becomes overheated, there is a tendency for pre-ignition of the combustible mixture to occur, thereby interrupting or impeding the descaling operation. It is therefore desirable to cool the head sufficiently to prevent overheating, preferably by circulating a suitable cooling medium, such as water, through the head.

Suitable apparatus constructed in accordance with the above principles is illustrated in Figs. 15 and 16, and includes an elongated upper block 83 and an elongated lower block 84, integrally secured together in a suitable manner, such as by welding, brazing, or silver soldering. Outlets 42'', similar to outlets 42 of head H, are drilled in the lower block, and a baffle or strip 72' is secured between the upper and lower blocks, as in the head of Figs. 13 and 14. The combustible mixture is fed into an upper channel 74', which distributes the mixture along the length of strip 72', the mixture thence flowing through holes or orifices 73' into a channel 75' formed between strip 72' and lower block 84. From channel 74', the mixture is discharged through orifices 73' so positioned as to prevent a direct flow of mixture into any outlet, and each orifice supplies an equal number of outlets, as before. The combustible mixture jets issuing from outlets 42'' will form heating flames impinging against scale on inner surface S'' of the upset end of a drill pipe P.

So that air jets may be directed downwardly towards surface S'', the upper portion of block 83 is relatively wide, and a plurality of slots 85 are formed in the lower sides thereof. Air is supplied to slots 85 by an air passage 86, and air jets directed from the slots will impinge upon surface S'' on either side of the row of heating flames, thereby blowing flying scale away from the heating flames as well as supplying additional oxygen for secondary combustion of the heating flames.

The top of block 84 is machined to form a relatively wide groove, air passage 86 being formed by the groove and a cover or cap 87 fitting over the upper block and integrally secured thereto in a suitable manner, such as by welding, brazing, or silver soldering.

Although air or oxygen, in passing through passage 86, produces some cooling of the head, it is normally desirable to circulate an additional cooling medium, such as water, through the head to prevent overheating thereof. For this purpose, cooling passages 88 are drilled in upper block 83, and cooling passages 89 are drilled in lower block 84. Passages 88 may be connected

by a cross-over 80 at the rear end of the head, and passages 89 may be connected by a similar cross-over 91, also at the rear end of the head. The cooling water may flow the length of the heating head through right hand passages 88 and 89, through cross-overs 90 and 91, and thence back through the left hand passages 88 and 89, or vice versa.

A protective conduit 92 secured to the head, at the front end thereof, serves as a handle for the heating head, and also encloses the various tubes and conduits (not shown) supplying the combustible mixture, water, and air or oxygen to the heating head. A tube supplying air or oxygen to the head is connected with passage 86, and a tube or conduit supplying the combustible mixture to the head is connected with upper channel 74'. A water inlet tube may be provided with two branches each of which is connected with one of cooling passages 88 and 89, while a water outlet tube may be similarly provided with two branches each of which is connected with the other of passages 88 and 89.

Skids 93, which space the heating head at the desired distance from surface S'', are secured to either end of the head in a suitable manner, such as by welding or silver soldering. Skids 93 are provided at the lower ends thereof with circular grooves or depressions having a curvature similar to that of the outer periphery of the upset end of the drill pipe, so that after the scale has been removed from the inner surface, the apparatus may be placed in operative position on the outer surface and the scale removed therefrom. Skids 93, in the same manner as skids 36 and 36' of the apparatus previously discussed, may be formed of, or provided with a deposit of, a suitable material which remains hard at relatively high temperatures, such as that previously described.

In removing scale from the inner surface S'' of pipe P, a relative rotation between the heating head and pipe P is employed. As soon as the scale has been removed from the inner surface, the heating head is removed from the interior of the tube, and placed upon the outer surface, a relative rotational movement again being employed. Pipe P may be mounted in a suitable machine, such as ordinarily used in pipe threading, in which the pipe is rotated; or the pipe may be rolled along a surface with the heating head held or supported in a suitable manner so as to follow along with the pipe. When the heating head is manually supported or guided, particularly within the interior of the pipe, a suitable baffle formed of heat-resistant material may be employed to deflect hot gases and secondary heating flames away from an operator. Such a baffle may be secured to conduit 92 adjacent the end of the pipe, and may have any suitable shape, such as corresponding to the end of the pipe.

While scale is being removed from the outer surface of the drill pipe end, the cooling water may, if desired, be turned off, since the head will no longer be within a substantially closed space. Furthermore, in the case of exceptionally large pipe, it may be unnecessary to circulate cooling water through the head, while removing scale from the inner surface, since a sufficient circulation of air into and/or through the pipe will occur and the secondary heating flames will not envelop the head to the same extent as in the case of smaller pipe. In other words, it is desirable to permit the head to become heated

to a temperature approaching, as closely as practical, that which would cause preignition or damage to the head, in order to increase the temperature and velocity of the heating flames for the purpose previously described.

Although the heating jets of each modification described have sufficient velocity to blow away freshly loosened scale, and a considerable amount of the scale pops up into the air in the form of relatively large particles, or chunks, such scale when blown away or popping off normally lands on the surface from which scale is being removed. If the scale lands ahead of the apparatus, it tends to pile up and accumulate until the depth of the pile is so great that the heating flames have insufficient velocity to move or blow away such a pile. Or, if the scale lands behind the apparatus, it is necessary to remove the same before the surface can be inspected. It has been found in many instances to be advantageous to move the scale to one side as soon as it becomes loosened to prevent any accumulation thereof on the surface from which the scale is being removed.

For moving the scale to one side, a properly directed air jet or jets may be utilized, or electromagnetic means. In Figs. 17 and 18, there is illustrated the apparatus of Figs. 1 and 2 so equipped that scale immediately after being loosened will be blown to one side by air jets; while in Figs. 19 and 20 there are illustrated the apparatus of Figs. 9 and 10, and Fig. 12, respectively, each equipped with electromagnetic means for carrying freshly loosened scale off to one side.

The equipment for blowing away loosened scale, as in Figs. 17 and 18, comprises a short pipe or conduit 95 connected at one end to the center of a U-shaped pipe having two branches 96 from each of which air is directed transversely across the surface from which scale is being removed. One branch directs air across and in front of the heating head, and the other branch directs air across and behind the heating head so that accumulated scale will be blown away when the apparatus of Figs. 1 and 2 is moved in either direction.

Since a considerable blast of air is delivered by each branch 96, such a blast would interfere with the normal operation of the heating flames if directed against the same. Consequently, branches 96 may be inclined downwardly toward the surface but away from the heating flames, as illustrated; or branches 96 may be positioned substantially horizontally so that the air jets will be directed across but above the surface. The latter position may be found desirable when the scale tends to pop off in relatively larger particles or chunks.

For supporting the air directing means, a bracket 97 is secured at one end to short pipe 95 in a suitable manner, such as by welding, and at the other end is secured to head H by bolt 35 which also secures one of the skids 36 to head H. Air is supplied to short pipe 95 by a hose or conduit 98 which is connected with a suitable source of supply of compressed air.

Suitable magnetic equipment for carrying away loosened scale, as in Fig. 19, includes two endless belts 100 supported adjacent the heating heads a short distance above and parallel to the upper surfaces S of billet B'. The lower halves of the belts are moved downwardly across the upper surfaces by rotating shafts 101 and 102, on which the belts are mounted. Magnets or electromagnets 103 are disposed between the

upper and lower halves of the belts, and are preferably slightly wider than the surface so that dislodged scale, which consists principally of magnetic iron and iron oxides, will be held against the belts by the force of magnetic attraction. A considerable portion of the scale will pop off and fly upwardly against the belts, or be blown upwardly against the belts by the heating flames, and the remainder of the scale will be pulled upwardly against the belts by magnetic forces.

The belts are provided with cross-bars 104 to prevent the scale from sliding, and the scale will be carried downwardly and out of the influence of the electromagnets to points adjacent lower shafts 102, where the scale will drop from the belts. Suitable chutes, hoppers, or receptacles may be provided beneath the lower ends of the belts to receive the scale as it drops off.

Suitable electromagnetic equipment for carrying away scale loosened from the top surface of the billet B' of Fig. 20 which is treated in flat position, includes an endless belt 100' which is similar to belts 100 and is moved horizontally and parallel to the top surface of the billet. Belt 100' may be moved in either direction by rotating shafts 101' and 102' since it is disposed in a horizontal position. An electromagnet 103' is disposed between the upper and lower halves of the belt, causing the loosened scale to be held against the belt, or to be picked up and held against the belt. As before, the scale will be carried to the side and away from the influence of the electromagnet, where the scale will be dropped; and the scale may be collected in a suitable manner.

It is normally unnecessary to provide magnets and belts or similar means to carry off the scale from the lower sides of the bloom or billet B' of Figs. 9, 10, and 19, or the bottom or sides of the billet B' of Figs. 12 and 20. The effect of gravity adequately insures the falling of loosened scale, which may be collected in suitable receptacles.

The apparatus of Figs. 9 and 10 and of Fig. 12 may each be equipped with air jets for blowing loosened scale to one side, but there are certain advantages to be obtained by the use of electromagnetic equipment. For instance, the scale contains iron and has a resale value, the electromagnetic equipment assisting in keeping the scale free of grease, dirt, and other foreign matter, and also assisting in the ease of collection. The foregoing advantage is more pronounced in the case of large scale operations in which a considerable amount of descaling is done. Again, the electromagnetic equipment "kills" or prevents scale dust, which may sometimes become obnoxious to workmen; and also prevents the larger particles from flying about, which are highly heated and dangerous to workmen or operators insufficiently protected. Nevertheless, air jets operate effectively, and are useful in a large number of cases.

Thin plates, sheets and continuous rolled billets which leave the final pass or rolls at relatively low temperatures, such as around 1600° F., are covered with the black scale previously mentioned, but this scale may be successfully removed in most instances by the high temperature and high velocity heating flames utilized in accordance with this invention. However, there are certain types of alloy steel forgings, (such as armor plate forgings, which are made of steel containing about 3.5% Ni and about 2%

Cr), which often require a special technique in removing the scale therefrom. The apparatus of Figs. 1 and 2 is useful in carrying out this special technique.

After forging, the armor plate is cooled slowly because of the air-hardening propensities of the steel forming the same, since it would be difficult and costly to machine the hardened steel. During this slow cooling, if the forging is relatively free of scale prior thereto, a black scale which forms thereon may be removed by heating as previously described herein. However, if scale of any appreciable thickness is present on the forging before it is cooled slowly, the resultant scale cannot be removed so easily. Such resultant scale is usually between one-half and three-quarters of an inch thick, and comprises an inner layer of reddish scale next to the plate, a central layer of heavy black scale, and an outer layer of reddish scale. This resultant scale tends to melt, rather than pop or fly off, when heated, and may be removed by melting. However, in the special technique employed in accordance with this invention, it is unnecessary to melt all of the scale.

In carrying out this special technique, the apparatus of Figs. 1 and 2 is utilized in melting a series of closely adjacent and merging holes through the scale, preferably by tipping the carriage C forwardly onto skids 36. The apparatus is then moved from 1 to 1½ inches away from the line of the first application of the heating flames, and the carriage C is again tipped forwardly to melt a second and substantially parallel series of closely spaced and merging holes, thereby producing a strip of unmelted scale 1 to 1½ inches wide. As soon as the second line of holes is melted, the carriage is tipped backwardly and the molten material blown forwardly onto the strip or bar of scale. This causes the bar of scale to buckle sufficiently so that a workman can insert a suitable instrument, such as a chisel edged bar, beneath the strip to remove the same. While this technique is more tedious and time-consuming than the method of normally removing scale as herein disclosed, it is still less tedious and time-consuming than chiseling alone, or sand blasting.

Although this invention has been described with reference to the treatment of billets, blooms, cylinders, tubes, etc., it will be understood that the principles thereof may be applied to the treatment of other ferrous metal bodies of different sizes and shapes. For instance, scale may be removed from irregular forgings and castings to uncover defects, or in preparation for machining, polishing, painting, etc. However, because of the irregularities in shape, it is sometimes desirable to connect head H directly to blowpipe 22 so that small surfaces may be descaled and access to grooves, slots, and holes may be had. In addition, relatively warm metal bodies may be treated to remove scale therefrom between two operations without cooling to atmospheric temperatures, to conserve heat for the second operation. Under normal operation, the temperature of the work is not materially increased by this method of descaling, and therefore there should be no fear of metallurgical harm. Scale at a temperature of 700° F. has been successfully removed, but further tests have indicated that at temperatures above 700° F., such as 900° F., the scale loses its stiffness and will not pop off, tending merely to flow or melt.

It will be further understood that changes in

the apparatus may be made in carrying out the method of this invention; and that other changes may be made without departing from the spirit and scope of this invention.

What is claimed is:

1. A method of removing scale from the surface of a ferrous metal body which comprises providing a combustible mixture of fuel gas and combustion-supporting gas; forming from such combustible mixture a jet having a velocity in excess of 600 feet per second; and directing against such scale a high temperature and high velocity heating flame formed by said jet.

2. A method of removing scale from a surface of a ferrous metal body which comprises directing against successive portions of such scale a plurality of high temperature heating flames, said heating flames being disposed closely together and having a velocity greater than that sufficient to blow away the loosened scale and at least sufficient to effect a rapid transfer of heat to said scale whereby a differential expansion between the top and the bottom of said scale normally is caused.

3. A method of treating a defective surface of a metal body, the defects of such surface including objectionable scale thereon, such method comprising the steps of forming a combustible mixture of gases; preheating said combustible mixture; directing such preheated combustible mixture through a plurality of outlets having a relatively small cross-sectional area so as to form a plurality of jets having an average velocity in excess of 600 feet per second; and directing the heating flames formed by said plurality of jets against successive portions of said surface.

4. A method of removing scale from the lateral surfaces of a metal body which comprises directing against successive longitudinal portions of such scale a plurality of high temperature heating flames, said flames being spaced closely together and having a velocity in excess of that sufficient to blow away loosened scale.

5. A method of removing scale from a surface of a metal body which comprises forming a combustible mixture of oxygen and a fuel gas having a ratio of oxygen to fuel gas greater than the neutral ratio of 1 to 1; passing such combustible mixture through a plurality of relatively long and constricted outlets; and directing the plurality of high velocity flames thereby produced against successive portions of such scale.

6. A method of removing scale from a surface of a metal body as defined in claim 5, in which said combustible mixture is preheated prior to its passage through said relatively long and constricted outlets so as to increase both the temperature and the velocity of said flames.

7. A method of removing tenacious scale from a surface of a ferrous metal body, such scale tending to melt upon the application of intense heat instead of becoming loosened by differential expansion, such method comprising melting portions of such scale along two substantially parallel lines so as to form a relatively narrow strip; heating such strip so as to cause the same to buckle, thereby permitting said strip to be removed by an instrument inserted beneath the same; and so producing and removing such strips over the remainder of said surface.

8. A method as defined in claim 7, of removing tenacious scale from a surface of a ferrous metal body, such scale tending to melt upon the application of intense heat instead of becoming loosened by differential expansion, in which

method said portions of scale are melted by high temperature heating flames; and said strip is heated by molten material blown onto the same by said flames.

9. A method of removing scale from the interior of a hollow metal body comprising directing a row of high velocity and high temperature heating flames against such scale; and supplying an oxygen-containing gas, discharged in jets disposed on each side of said row of heating flames, to support the secondary combustion of said heating flames.

10. Apparatus for treating a surface of a metal body so as to remove scale therefrom, such apparatus comprising a heating head having a plurality of outlets for directing a plurality of high temperature heating flames against such scale; means for supplying said head with a combustible mixture of oxygen and a fuel gas; means for supporting said head; means for effecting a relative movement between said heating head and said surface longitudinally of said surface; means contacting said surface for spacing said heating head at a desired distance from said surface and also for following irregularities in contour of said surface; and resilient means for maintaining said contacting means against said surface.

11. Apparatus for treating a defective surface of a metal body so as to remove scale therefrom, comprising a heating head having a plurality of outlets for directing a plurality of high temperature heating flames against such scale; means for supporting said heating head; means for effecting a relative movement between said head and said surface; means for supplying said outlets with a combustible mixture of gases; means contacting said surface for spacing said head at a desired distance from said surface and for following irregularities of contour in said surface; resilient means for maintaining said contacting means in contact with said surface; and motion resisting means for preventing a rapid movement of said head away from said surface when said contacting means encounters unusual contours in said surface.

12. Apparatus for removing scale from the surface of a ferrous metal body comprising means for directing high velocity and high temperature heating flames against successive portions of such scale so as to cause the same to become loosened by differential expansion; and additional means for removing, from the path of travel of said heating means relative to said surface and ahead of said heating means, loosened scale tending to interfere with the operation of said heating means.

13. Apparatus for removing scale from the surface of a ferrous metal body as defined in claim 12, in which said additional means for removing loosened scale includes means for directing a jet of compressed gas transversely to the relative path of travel of said heating means.

14. Apparatus for removing scale from the surface of a ferrous metal body as defined in claim 18, in which said additional means for removing loosened scale includes a belt moving transversely to the direction of relative travel of said heating means; and means for producing a magnetic field which will cause such loosened scale to be held against said belt and so removed.

15. Apparatus for treating a defective surface of a metal body to remove scale therefrom, comprising a heating head having an inlet and a plurality of outlets for directing a plurality of

high temperature heating flames against such scale; a distributing chamber connected with said outlets; and a plurality of passages connecting said inlet and said distributing chamber and each so disposed as to cause the flow of a combustible mixture therethrough to impinge against the wall of said chamber at points between two of said outlet passages, said connecting passages also being disposed so that each will tend to supply an equal number of outlets with the combustible mixture.

16. A blowpipe for producing a plurality of high temperature heating flames comprising a block having a plurality of discharge outlets drilled therethrough; a second block integrally united to said first-named block, said blocks forming at least one passage therebetween for distributing a combustible mixture of gases to said outlets and said second block having at least one passage for conducting such combustible mixture to a distributing passage; said outlets each having an enlarged entrance portion and being drilled in said first-named block prior to its being united to said second block whereby said entrance portions may be enlarged and burrs and the like may be effectively removed from the entrance of said outlets to insure a smooth flow of such combustible mixture into said outlets.

17. Apparatus for removing scale from the surface of a ferrous metal body comprising a blowpipe as defined in claim 16, in which said outlets are relatively long and narrow whereby

heating flames having a relatively high velocity are produced.

18. Apparatus for removing scale from the interior of a hollow metal body comprising an elongated blowpipe head having a row of outlets for directing high temperature heating flames against such scale; and means for directing jets of an oxygen-containing gas adjacent said heating flames, on each side of said row thereof, for supporting secondary combustion of said heating flames.

19. Apparatus for removing scale from the interior of a hollow metal body as defined in claim 18, in which said outlets are disposed in a single row, and said head is provided with a passage through which such oxygen-containing gas is passed; and outlets connecting with said passage for directing jets of such oxygen-containing gas toward said scale and on each side of said heating flames.

20. A method of removing scale from the surface of a ferrous metal body comprising forming a combustible mixture of fuel gas and combustion-supporting gas; passing such combustible mixture through a plurality of relatively long outlets having a discharge section of a length greater than twelve times the diameter thereof; and directing against such scale a plurality of heating flames formed by said combustible mixture discharging from said outlets and having a velocity in excess of that sufficient to blow away loosened scale.

EIBE W. DECK.

CERTIFICATE OF CORRECTION.

Patent No. 2,282,397.

May 12, 1942.

EIBE W. DECK.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 8, second column, line 66, claim 14, for the claim reference numeral "18" read --12--; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of July, A. D. 1942.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.