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C. MOTT ET AL

2,254,307

FLAME HARDENING

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FIG. 1.

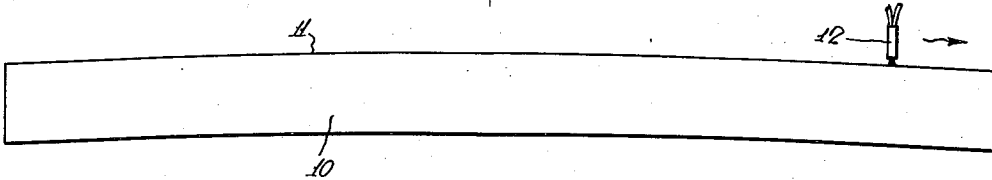


FIG. 2.

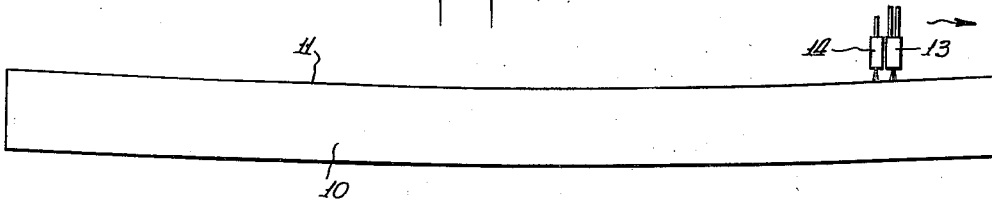


FIG. 3.

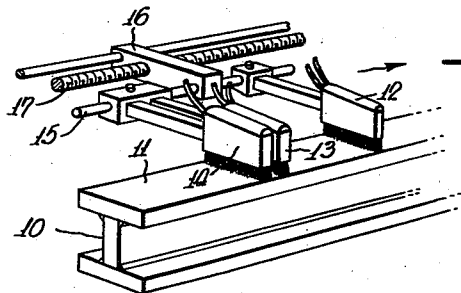
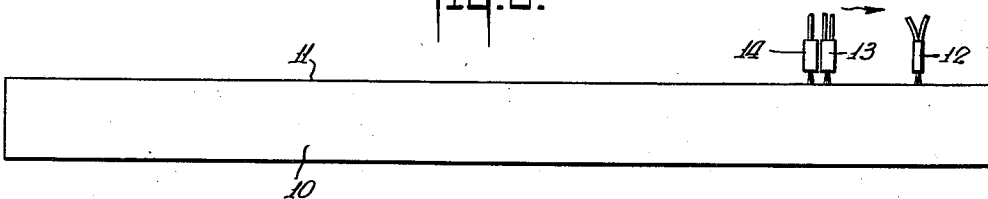


FIG. 4.

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FLAME HARDENING

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7 Claims. (Cl. 148—21)

In the ordinary process of flame hardening a surface of a metal member, a sheet-like flame is applied to the surface on an area extending transversely thereof, and from an oxy-acetylene or other analogous burner. The flame is moved at a controlled rate of speed along the surface in a direction at right angles to the plane of the flame, and jets or preferably a sheet-like jet of water from a suitable nozzle follows the flame at a short distance therefrom. The flame is of such heating capacity, and its speed of movement along the surface is such that successive narrow areas are heated to the critical temperature, and these areas are quickly chilled by the water immediately after the flame leaves them.

If the member be of considerable length in respect to its cross-section, and the surface had previously been machined, ground or otherwise finished to present a smooth surface in a predetermined plane, it has been noted that in many instances the flame hardening caused the surface to become slightly concave. It is very difficult to refinish the surface to the original plane, because the flame hardening of the surface renders it very hard and resistant to ordinary cutting or grinding tools. The production of a hardened surface in a true and predetermined plane is very important in many types of apparatus, for instance where the surface is to act as a guide for a tool or other traveling part of the apparatus.

So far as we are aware, no satisfactory method has heretofore been devised for overcoming this difficulty. The cause is not entirely clear, but it is believed that the curvature may be due to the fact that as the very high temperature is applied in heating successive portions of the surface to the critical temperature, it softens the metal very rapidly and does not cause any appreciable expansion of the metal in the direction of the length, and therefore no tendency to cause convex curvature while hot. It is thought that such expansion as does take place during the localized heating is in the soft metal, and at right angles to the surface. In other words, it causes a slight increase in thickness because the metal is very soft at its critical temperature and expands in the direction offering the least resistance. When the very hot metal is suddenly chilled by the jet of water, the first contraction may take place at right angles to the surface to restore the original thickness; but further contraction takes place in the direction of the length of the surface during further cooling and causes stress which results in the slight bending of the member and the resulting slightly concave sur-

face. The curvature may be a very appreciable fraction of an inch if the member be several feet long, and of such cross-section as permits bending or warping under the developed stress.

We have discovered a method whereby the difficulty above referred to may be overcome.

In our improved process we mount a pilot burner a short distance ahead of the main heating and flame hardening burner, and advance the two burners at the same rate along the surface. The second burner may be of the same general type as the main burner, that is, it delivers a sheet-like flame extending transversely of the surface, but of such a size that at its rate of travel it heats the metal to a temperature below a set heat, and not to its critical temperature. The relative size of the burner may be such that the flame or gas consumption of the pilot burner is only about 10% of that of the main or hardening burner. It may be varied in size according to the character of the article being treated, but ordinarily is not more than 15% or less than 5% of the heating capacity of the main burner.

The spacing of the burners may vary with the speed of travel, but in most cases it has been found that a spacing of about 10 inches is satisfactory. The two burners may be rigidly but adjustably connected together and advanced by the same traveling support.

By the use of the pilot burner traveling with, but in advance of, the flame hardening burner, it has been demonstrated that the surface of a very long and relatively bendable metal member may be successfully flame hardened without bending, warping or other distortion, and the hardened surface after the chilling will be in the same plane as it was before the hardening, and no concaving effect is produced.

The exact reason why the new and highly desirable result is secured by the use of our process is not known with certainty, but it is believed that the pilot flame causes an expansion of the metal at the surface, and because the metal is not heated to its critical point the resulting expansion is lengthwise of the member and tends to, or actually does, produce a convex surface. It is this convex surface which is suddenly heated to the critical temperature by the main flame, and the expansion of the soft metal and the initial contraction by the jet may be at right angles to this convex surface, and the final contraction caused by the water jet counterbalances both the upward expansion due to the main flame, and the longitudinal expansion due to the pilot flame, so that the surface after the cooling is in the same

plane that it was in before the beginning of the process.

Whether or not the theories advanced above are correct is immaterial. The observed fact is that by means of our process the tendency to permanent distortion of the surface is overcome, and no further machining or grinding of the surface is required to restore it to its original configuration or shape.

In the accompanying drawing the apparatus parts are diagrammatically illustrated, and there is indicated to a very much exaggerated extent, the action which may take place.

Fig. 1 shows a bar having the heated surface rendered convex by the action of a pilot flame alone.

Fig. 2 shows the bar having the surface rendered concave by a flame hardening burner and chilling jet.

Fig. 3 shows the bar having the surface unchanged as to shape by the successive actions of the two spaced burners and the cooling jet, and

Fig. 4 shows in perspective the bar which may be treated and the apparatus parts interconnected for simultaneous movement.

In the drawing the burners are movable in the direction indicated by the arrows, and in Figs. 1 to 3 are shown near the end of the path of movement. The bar 10 has a surface 11 which is to be flame hardened. The surface is shown convex in Fig. 1 by the expansion due to the pilot burner 12 alone. It is shown concave in Fig. 2, due to the contraction following the action of the flame hardening burner 13 and the trailing water jet from the nozzle 14, and in Fig. 3 it is shown flat after successive action of the pilot burner, the flame hardening burner, and the water jet.

In Fig. 4 the pilot burner 12, the main burner 13, and the water nozzle 14 are shown as connected to a supporting member 15 and adjustable toward and from each other on said member. The supporting member is shown as secured to a carrier 16 threaded on a screw shaft so that by rotating the latter the carrier is moved along the bar 10 at the desired controlled speed.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is:

1. The method of flame hardening a longitudinal surface of a metal member and inhibiting permanent warping, which includes preliminarily heating said surface to a temperature below the critical temperature to initially warp the member, further heating the warped surface progressively along the length thereof to the critical temperature, and progressively chilling the heated surface.

2. The method of flame hardening a longitudinal surface of a metal member and inhibiting permanent warping, which includes advancing a preheating flame along the surface, the flame being of such heating capacity and the advancing movement of the flame being at such a rate, that the surface is heated to a temperature below a red heat and the metal at the surface is expanded, advancing a second flame along said heated surface, the flame being of such heating

capacity and the advancing movement being at such a rate as to heat successive portions of the surface to the critical temperature, and advancing a cooling jet along said surface adjacent to but spaced in the rear of said second flame.

3. The method of flame hardening a longitudinal surface of a metal member and inhibiting warping tendencies, which includes preliminarily heating the surface to expand the metal of the surface portion, thereafter heating said surface to the critical temperature, and thereafter chilling said surface, all of said steps being performed simultaneously and progressively along the surface at spaced distances apart.

4. The method of flame hardening a longitudinal surface of a metal member and inhibiting warping tendencies, which includes progressively advancing a sheet-like preheating flame along said surface to expand the metal at said surface, progressively advancing a main sheet-like heating flame along said surface, progressively advancing a sheet-like cooling jet along said surface, said preheating flame, main flame and cooling jet being at predetermined distances apart, and the heating capacities of the flames and the rate of travel being such that the preheating flame heats successive portions of the surface to a temperature below a red heat, the main flame heats successive portions to the critical temperature, and the cool jet removes heat applied by both burners.

5. An apparatus for flame hardening a longitudinal surface of a metal bar without permanent warping, which includes a main burner, a preheating burner in advance of the main burner and having a heating capacity equal to approximately one-tenth that of the main burner but sufficient to expand the metal at said surface, a nozzle in the rear of the main burner for delivering a jet of cooling fluid to the metal heated to a critical temperature by the flame of the main burner, and means for progressively moving said burners and nozzle along the surface at the same rate, and at predetermined distances apart.

6. An apparatus for flame hardening a longitudinal surface of a metal bar, which includes a main burner, a preheating burner in advance of the main burner to initially curve the bar, a nozzle in the rear of the main burner for delivering a jet of cooling fluid to the metal heated to a critical temperature by the flame of the main burner, and means for progressively moving said burners and nozzle along the surface at the same rate, and at predetermined distances apart.

7. An apparatus for flame hardening a longitudinal surface of a metal bar, which includes a main burner, a preheating burner in advance of the main burner to initially curve the bar, a nozzle in the rear of the main burner for delivering a jet of cooling fluid to the metal heated to a critical temperature by the flame of the main burner, means for progressively moving said burners and nozzle along the surface at the same rate, and at predetermined distances apart, and means for adjusting the spacing between the main and pilot burners.

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