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INDUCTION HEATING AND QUENCHING APPARATUS

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1

My invention relates to induction heating and quenching apparatus, more particularly to induction heating and quenching apparatus for the continuous hardening of metal parts and has for its object simple, reliable and compact induction heating and quenching apparatus.

More specifically, my invention relates to the continuous surface heating and hardening of massive metal parts such as the rails or ways on lathe beds by means of high frequency induction heating wherein the workpiece and the heating coil are moved relative to each other so as progressively to heat the surface area of the workpiece. This method of heating requires the application of the quenching fluid or medium progressively to the workpiece as it emerges from heating relation with the coil. I have found that when a separate quenching means is provided the workpiece may cool appreciably while moving into operative relation with the quenching means.

In accordance with my invention I provide means carried by the heating inductor for applying a quenching fluid to the article continuously in such manner as to quench the article immediately after it has been heated.

In carrying out my invention in one form I provide an induction heating coil provided with apertures in a trailing portion of the coil for directing a cooling fluid onto the workpiece as it emerges from heating relation with the coil.

For a more complete understanding of my invention reference should be had to the accompanying drawing in which Fig. 1 is a fragmentary view partly in section of induction heating and quenching means embodying my invention as applied to the rail or way of a lathe bed, Fig. 2 is a sectional view taken along the line 2—2 of Fig. 1 looking in the direction of the arrows, Fig. 3 is a fragmentary plan view of the apparatus shown in Fig. 1, Fig. 4 is an enlarged fragmentary sectional view of the workpiece and quenching portion of the heating coil, while Fig. 5 is a fragmentary view showing a modified form of my invention.

Referring to the drawing I have shown my invention in one form as applied to the surface heating and hardening of a massive rail 1 of a lathe bed constituting a workpiece. It is desired to harden a thin wearing surface layer 2 on the rail. In accordance with my invention I heat this surface layer 2 to a hardening temperature by means of a hairpin shaped induction heating inductor or coil 3 formed from electrically conducting hollow or tubular material such as 1/4" copper tubing. The two parallel lengths of

2

the coil 3 are shaped and suitably supported to lie in planes parallel with the plane wearing surfaces of the rail, one portion 4 being parallel with the top of the rail and another portion 5 being parallel with the beveled edge of the rail. To provide a uniform thickness of the heated layer the opposite end portions 6 and 7 of the coil extend beyond and are bent away from the edges of the rail and a loop 8 is provided around at the junction of the beveled edge with the top of the rail in greater spaced relation with the junction.

The rail and heating coil are mounted on suitable supporting means (not shown) for relative movement with respect to each other so that during the heating operation the coil passes continuously at a uniform speed along the upper surface of the rail in parallel spaced relation therewith. Preferably as shown in the drawing the coil extends transversely of the rail and the relative movement is in a direction lengthwise of the rail and hence transversely of the coil. Generally I prefer to move the rail or other part being heated relative to the coil because a moving coil requires flexible leads which are objectionable with high frequencies on account of the high power losses incident thereto. This scanning speed is selected to provide for the gradual heating of a surface layer 2 of a desired thickness to the hardening temperature.

During the heating operation current is supplied to the coil from supply connections 9 and 10 at a suitable high frequency such as 540,000 cycles a second. Also a cooling fluid, preferably water, is circulated through the hollow conductor of the coil, as indicated by the arrows 11 and 12, for the purpose of cooling the coil.

In accordance with my invention I utilize a portion of the cooling water supplied to the heating coil to quench the heated portion of the rail. To effect this I provide a series of equally spaced apertures 13 in the trailing left-hand arm of the hairpin coil, assuming that the coil is moving relatively toward the right-hand. With the coil stationary the rail is moved in the opposite direction, i. e., toward the left-hand as indicated by the arrow 14. The apertures 13 moreover are in such positions, as shown in Figs. 2 and 4, in the trailing wall of the tubular conductor as to direct the cooling water downward onto the heated surface at such an acute angle with the heated surface as to strike the heated portion just as it emerges from under the coil and while it is heated to a maximum desired decalescent temperature. As shown, the apertures 13 are drilled radially

through the wall of the tubular conductor but at a substantially 45° angle with the vertical on the trailing side of the coil.

It will be understood that cooling water is supplied continuously under a suitable pressure to the coil when the coil is energized and a portion of the cooling water is projected or sprayed in a series of jets 15 from the holes 13 which are close enough together to form a continuous zone of application or curtain of cooling water applied to the work-piece. If desired, a separate spray pipe carried by the heating coil may be provided.

The progressive heating of the surface layer 2 by the two arms or lengths of the heating coil to the hardening or decalescent temperature is indicated diagrammatically in Figs. 2 and 4. As shown in Fig. 2 the right-hand or leading arm of the coil effects the heating to a substantial part of the desired depth with slight cooling until the left-hand or trailing arm is reached when the heating is completed to the desired depth.

It will be understood that my invention is useful with various shapes of heating coils and is not limited to the hairpin shaped coil disclosed in Figs. 1 to 4, inclusive.

As shown in Fig. 5, the single turn coil 16 surrounds the parts 17 being heated. The part 17 is moved downward through the coil whereby its surface is progressively heated by the coil and then quenched by the cooling water spray 18.

While I have shown a particular embodiment of my invention, it will be understood, of course, that I do not wish to be limited thereto since many modifications may be made and I therefore contemplate by the appended claims to cover any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. High frequency induction heating and quenching apparatus for the continuous surface hardening of a metal article having two surfaces joined together at an angle with each other, said apparatus comprising a substantially round tubular hairpin-shaped induction heating coil made entirely of electrically conducting material constructed and arranged for the continuous circulation of cooling water therethrough and arranged to extend across said surfaces transversely of the junction thereof, said coil being arranged for relative movement with respect to said surfaces parallel to said junction, said coil being shaped to provide a separate heating and quenching portion for each of the two surfaces to be heated, each such portion having a pair of substantially parallel spaced apart lengths of tubing extending in parallel spaced relation with the corresponding one of said surfaces and passing successively thereover in cooperative heating relation therewith, each length of each said pair being joined to the adjacent length of the other pair by a loop portion extending around said junction in greater spaced relation therewith, and electric connections for passing a high frequency current through said coil so that said coil heats said surfaces up to a predetermined hardening temperature, each of the trailing ones of said lengths being provided with a plurality of spaced substantially radially extending apertures extending at an acute angle with its corresponding surface in the direction of relative movement of the article so as to project a portion of said cooling fluid directly onto the article

to engage and cool the heated surfaces of the article as they emerge from under said trailing lengths and while they are still heated to said predetermined hardening temperature.

2. High frequency induction heating and quenching apparatus for the simultaneous continuous surface hardening of two plane surfaces of a metal article joined together at an angle with each other, said apparatus comprising a substantially round tubular hairpin-shaped induction heating coil made entirely of electrically conductive material constructed and arranged for the continuous circulation of cooling water therethrough and arranged to extend across said surfaces transversely of the junction thereof, said induction heating coil being arranged for relative movement with respect to said surfaces parallel to said junction, said coil being shaped to provide a separate heating and quenching portion for each of the two surfaces to be heated, each such portion having a pair of substantially parallel spaced apart lengths of tubing extending in equidistant spaced relation with one of said surfaces and passing successively thereover in heating relation therewith, a pair of loop portions of said coil extending around said junction in greater spaced relation therewith and joining each length of each said pair to the adjacent length of the other pair, said coil being provided with a portion at each end extending beyond and away from the edges of said plane surfaces, and electric connections for passing a current having a frequency of substantially 500,000 cycles a second or more through said coil whereby the leading and trailing lengths of said portions cooperate in heating a uniform layer under said surfaces up to a predetermined hardening temperature, the trailing ones of said lengths being provided with a plurality of spaced substantially radially extending apertures extending at an acute angle with said surfaces in the direction of relative movement of the article so as to project a portion of said cooling fluid directly onto the article to engage and cool the heated surfaces of the article as they emerge from under said trailing lengths and while said heated surfaces are still heated to said predetermined hardening temperature.

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