Aug. 22, 1939. F. S. DENNEEN ET AL 2,170,130

METHOD OF AND APPARATUS FOR HARDENING A METAL ARTICLE

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Fig. 1.

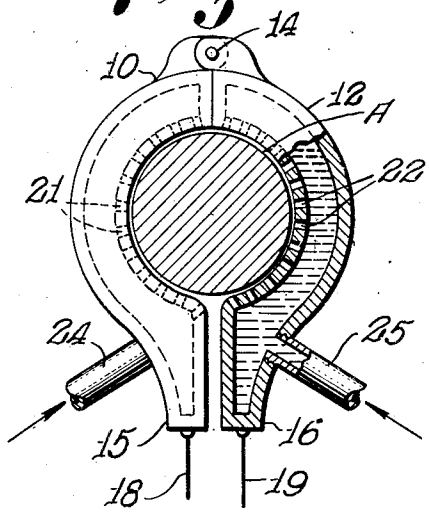


Fig. 2.

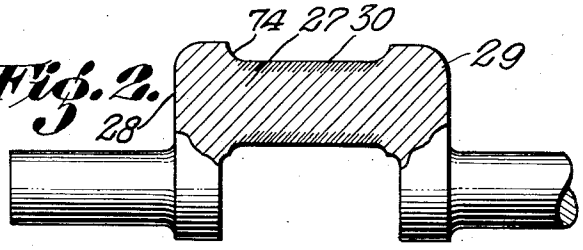
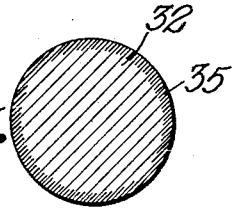


Fig. 3.



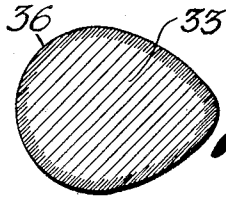


Fig. 4.

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METHOD OF AND APPARATUS FOR HARDENING A METAL ARTICLE

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2 Claims. (Cl. 266—4)

The present invention, relating as indicated to a method of metal hardening is more particularly directed to a method for treating an article to provide a uniformly case-hardened surface or surface zone, such for example as a crankshaft, camshaft or other piece in which one type of physical characteristics are required in the central or body portion of the article and a hardened surface zone is required for the purpose of resisting wear or the like, and to a new and improved method of rapidly and efficiently making same.

A further object of the invention is the provision of a method of and apparatus for rapidly and uniformly hardening the outer layer or zone of a metal article where the ordinary methods, such as the ordinary surface hardening operation, nitriding, or the so-called case hardening, produce either an irregular or non-uniform thickness of the hardened zone which requires additional finishing work on the article and sometimes causes loss of the entire piece, and/or warping or distortion of the entire article.

To the accomplishment of the foregoing and related ends, said invention, then, consists of the means hereinafter fully described and particularly pointed out in the claims; the annexed drawing and the following description setting forth in detail one method and one product exemplifying our invention, such disclosed procedure and product constituting, however, but one of the various applications of the principles of our invention.

In said annexed drawing:

Fig. 1 is an end elevation of our improved apparatus for heating and rapidly quenching a heated article to be hardened; Fig. 2 is a side elevation partially in section of a surface-hardened article produced by our improved method and showing the uniformity of the hardening treatment; Figs. 3 and 4 are transverse sections, respectively, of a cylindrical article and of an irregular article such as a cam when treated by our method.

In the manufacture of such articles as crankshafts, camshafts, hardened pins and other similar articles, it has been the custom to form articles from a low-carbon content steel which usually does not exceed .20% and to then carburize the surfaces to be hardened, after which the case hardened surface is produced by heating and then quenching in the usual manner. This method is open to the objections that the pieces often become deformed during the case hardening process and frequently cannot be straightened without breakage, and during straightening minute cracks develop in the hardened surfaces which are very difficult to detect and often result in the fracture of the finished piece under load while in service. A further objection to the ordinary method is that in many articles, such as crankshafts for example, it is desirable to keep the weight and size to a minimum, but if the shaft must be hardened, this prevents the use of certain high tensile strength alloy steels in which the strength is secured by heat treatment, as the ordinary case hardening proces destroys the result of the heat treatment. A still further serious objection to the ordinary procedure is that case hardening cannot be closely controlled as to the depth of the hardened zone and this depth cannot even be closely measured after hardening, so that pieces which have been case hardened by ordinary methods are always subject to uncertainty of performance during use. The so-called nitriding of articles for the purpose of hardening is superior in some ways to the ordinary pack method of case hardening, but still produces warping and distortion, and warped or distorted articles after straightening frequently have minute cracks which are difficult to detect and which frequently cause breakage in service.

With our improved method it is posible, and of course frequently desirable, to use either ordinary carbon steels having a carbon content of .30% or higher, or any of a wide range of alloy steels that by heat treatment have been given increased physical strength and certain other desirable characteristics, not possessed by ordinary low carbon steels. This is possible because the process now to be described permits hardening to any desired depth and to any desired hardness with substantially no detrimental effect to the steel or to the physical properties imparted to it by the heat treatment previous to the surface hardening.

Referring now to Fig. 1 we have shown a fixture consisting of two semi-cylindrical jaws 10 and 12 hinged together at the pin 14 and provided with extensions 15 and 16, to which are connected conductors 18 and 19 leading to a source of high frequency current.

The members 10 and 12 are hollow, are provided with spray nozzles 21 and 22, and cooling fluid is provided to the interior of the two members by means of connections 24 and 25. In this apparatus the heating effect is uniform and continuous around a cylindrical article *a* mounted between the two members and the article therefore does not necessarily require to be rotated to produce a uniform heating all over the surface as in the preceding cases. The introduction of the cooling fluid serves the double purpose of quenching the article which is being

case hardened and cooling the electrodes which otherwise, after repeated or continuous operation, would become too hot for continuous service. In the construction shown in Fig. 1, the article to be hardened may be spaced very slightly from the surfaces of the electrodes and the heating produced in the surface of the article is accomplished by the action of the current established in the surface zone of the article.

We have found that the heating and the depth of penetration of the heat can be varied and closely controlled by the use of the proper frequency, preferably high and approximating 1000 or more cycles per second, the proper current density flowing through the electrodes, the proper spacing from the electrodes to the surface to be hardened, and the proper time duration of the application of the current to the electrodes. By proper combination of the foregoing, it is possible to heat the desired surface hot enough to permit hardening by quenching or cooling, the entire process being carried out so quickly that the heat is not given time enough to penetrate or travel beyond the zone to be hardened, to a degree sufficient to effect or change the physical qualities imparted to the steel prior to the surface-hardening process.

In Fig. 2 we have shown a crankshaft in which the pin 27 between the cranks 28 and 29 has been hardened by our improved method to produce a hardened zone 30, which is uniform in depth and which is shaded or narrowed at either end as the pin 27 merges into the cheeks or flanges 28 and 29. This merging of the hardened area and thinning of this area is an important and valuable characteristic of our present method, as the hardening of any piece can be graduated as may be desired to prevent sharp changes in the character of the metal and to leave unhardened those portions which it is desired to leave in their original heat-treated condition.

In Figs. 3 and 4 we have shown a cylindrical article 32 and a cam-shaped article 33 provided with hardened surface areas 35 and 36 respectively, which can be graduated precisely as desired by our improved method.

For convenience, we have referred at various points of the description and claims to "crankshafts" or "camshafts", but it will be understood that the term "crankshaft" or "camshaft" as used herein is employed for convenience only and is used to define any article which may desirably be subjected to our improved method of surface hardening for the purpose of producing a zone of hardened material over a selected part or all of the article. Similarly, the term "core" as used herein is intended to embrace not only those portions of the article to be treated directly underlying the surface which is to be case hardened, but any and all other portions of the article which are not being case hardened and which it is desired to maintain in their original condition with their original physical characteristics. The term "enclosed" as further employed, denotes not only the contacting of the portion of the article to be treated, but the disposition of an electrode in a position closely adjoining the selected portion of the surface to be treated even though the electrode is slightly spaced therefrom. Likewise, the use of the terms "heat treatment" and "heat treated" is primarily intended to include the process of heating and sudden cooling or quenching, as distinguished from the use of the terms in their broader sense which might include an annealing process.

It will also be understood that many irregularly shaped articles not specifically mentioned herein may be similarly provided with a hardened surface zone by being subjected to the treatment described in suitably shaped electrodes formed to extend very closely adjacent to the surfaces of the article which it is desired to harden. In all cases this of course permits of the selection of a material and of an initial treatment of a material which will give it the most desirable physical characteristics for a given service, after which the surface hardening at selected parts may be provided without in any way detrimentally affecting the physical characteristics already imparted to the articles.

We have found that various quenching fluids may be employed, the selection of the particular fluid depending upon the kind and size of the article being hardened. For example, in the hardening of relatively thin or small articles, a cooling air blast may be employed for rapidly quenching the heated surface zone, while with other articles ordinary liquids, such as water, are more desirable. We have also found that for extremely rapid cooling a relatively strong solution of sodium hydroxide, or equivalent material, is extremely effective, as such a liquid cools the heated surface more rapidly than water and reduces the penetration into the body of the article.

Other modes of applying the principle of our invention may be employed instead of the one explained, change being made as regards the product and the means and steps herein disclosed, provided those stated by any of the following claims or their equivalents be employed.

We therefore particularly point out and distinctly claim as our invention:

1. In a heating and quenching device a hollow inductor coil adapted to surround a charge to be heated, holes in said hollow coil on the charge adjacent side and means for projecting a quenching medium through the holes onto a charge with such volume and force that vapor pockets formed between the quenching streams and the charge will be a minimum.

2. In a method of heating and quenching a surface zone of an article, the steps of placing an inductor in spaced heating relation to an article with the inductor as a primary to inductively heat the article as a secondary of the said inductor, connecting the inductor to a periodically varying source of electric current to inductively heat said article and thereafter quenching the article by projecting from the interior of the inductor against the article a quenching medium with such volume and force that vapor pockets formed between the quenching streams and the charge will be a minimum.

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