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METHOD AND DEVICE FOR HARDENING OF ARTICLES
BY HIGH-FREQUENCY CURRENTS
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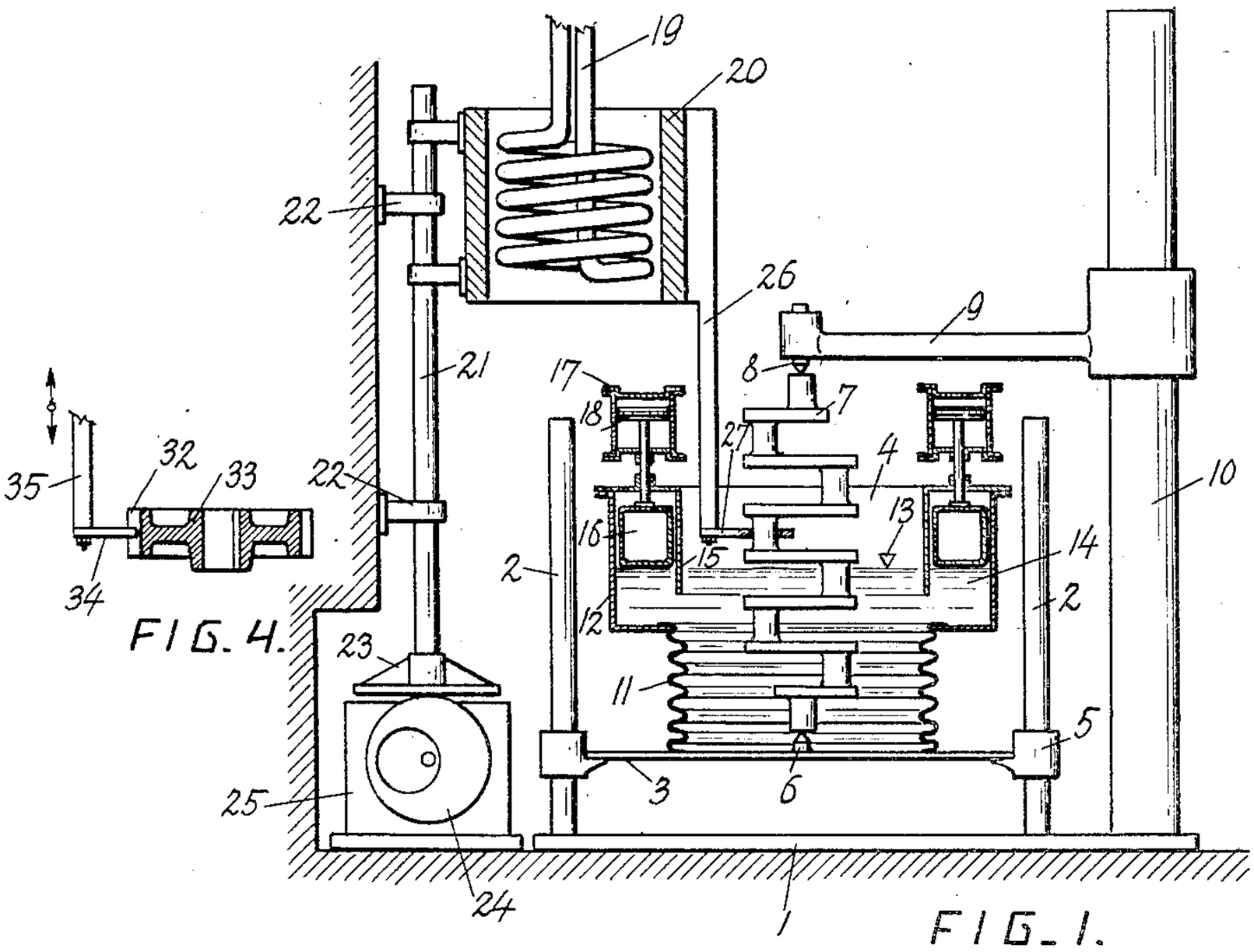

FIG. 4.

FIG. 1.

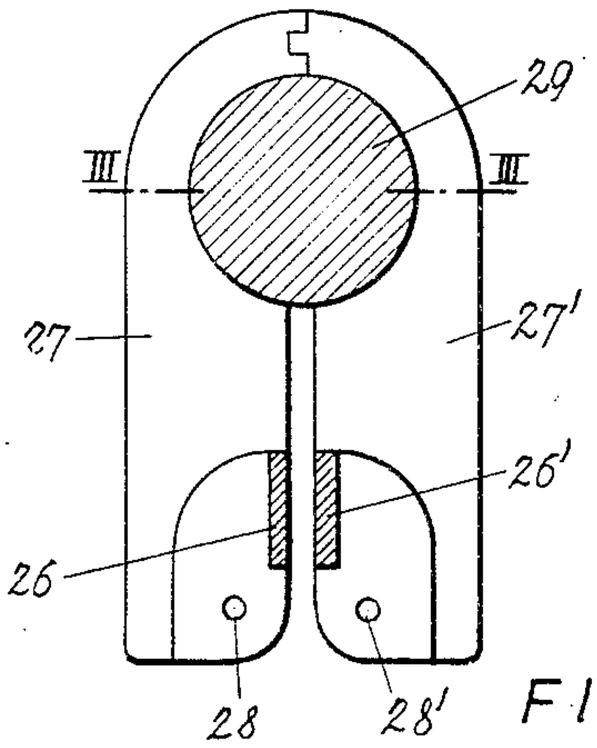

FIG. 2.

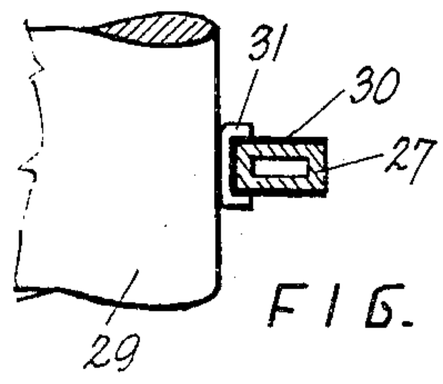

FIG. 3.

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METHOD AND DEVICE FOR HARDENING OF ARTICLES BY HIGH-FREQUENCY CURRENTS

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5 Claims. (Cl. 219—13)

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The present invention relates to a device for hardening of articles, such as journals or bearing journals of crankshafts or the like, by the use of high frequency currents.

In up-to-date hardening processes high frequency currents are often used for heating of surface layers to be hardened, said high frequency currents being induced in such layers by means of a so called heating inductor, having the shape of a coil surrounding the heated article and supplied by high frequency currents in any suitable way.

It is an object of the present invention to provide a device by which uniform hardening of elongated articles may be obtained.

Further objects and advantages of the invention will appear from the following description with reference to the annexed drawings in which:

Fig. 1 shows in vertical section a device according to the present invention adapted for hardening a crankshaft journal,

Fig. 2 shows the heating inductor in plan view and at a larger scale

Fig. 3 shows the arrangement of the heating inductor in cross-section along the line III—III from Fig. 2 in a slightly modified arrangement and

Fig. 4 shows the application of the invention to the hardening of gear-teeth.

Fig. 1 shows the general layout of the device, adapted for the treatment of crankshaft journals. To a base 1 suitable mountings, such as columns 2, are secured on which a bottom plate 3 of a quenching container marked generally by the reference numeral 4, which will be more fully described hereinafter, is mounted adjustably in vertical direction. The bottom plate 3 is supported by suitable supports 5, adapted to slide along the columns 2 and to be secured in the desired position by any suitable means, such as screws, clamps or the like (not shown). The bottom plate 3 is provided with a pointed pin 6, serving as a bearing for the crankshaft 7, the journals of which have to be hardened, the other end of the crankshaft being supported by a similar pointed pin 8, so that the crankshaft 7 is mounted in vertical position and may be rotated around a vertical axis. The pin 8 is supported by an arm 9, mounted adjustably in vertical direction on a pillar 10. The arm 9 is preferably arranged so as to be movable up and down together with the bottom plate 3, e. g. by a suitable gearing or the like (not shown).

The container 4 for the quenching liquid consists of a lower part 11 shaped as a bellows so as to allow the bottom plate 3 to be moved up and down without the position of the fixed upper part 12 of the container being changed. The container is filled with a suitable quenching liquid up to a desired level, determined by an aperture 13, which can be closed by any suitable closing means, which are not shown in the drawings.

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In the upper part of the container a circular space 14 is provided by an annular partition 15. A displacing body 16 of any suitable shape and size is mounted for vertical movement in the circular space 14, for instance by means of a hydraulic or pneumatic device, consisting of a cylinder 17 and piston 18, to which the displacing body 16 is secured.

The heating portion of the device comprises a transformer consisting of a primary winding 19 and of a secondary winding 20 which in the embodiment shown has the shape of a split ring 20. The ring 20 is secured to a vertical rod 21, guided for vertical movement in suitable guides 22, 22. On a suitable point e. g. on the lower end of the rod 21 a transverse slide 23 is arranged, cooperating with an eccentric or cam 24, driven by any suitable driving means 25. During rotation of the eccentric 24 reciprocal movement in vertical direction is imparted to the rod 21 and to the transformer ring 20, which, being of sufficient length, remains permanently in a proper coupling position with the primary winding 19.

Leads 26, 26' (see also Fig. 2) extend from the split ends of the ring 20. On their lower ends the leads are provided with a heating head or inductor, denoted generally by 27 in Fig. 1. The heating head as shown in Fig. 2 consists of two halves or jaw portions 27, 27' mounted for swinging movement around pivots 28, 28'. At the other end of the heating head a suitable aperture 29 is provided for the reception of the journal to be heated.

The described device operates as follows:

The crankshaft 7 the journals of which have to be hardened, is placed between the pins 6 and 8; the bottom plate 3 together with the arm 9 are then simultaneously raised or lowered to such an extent, that the journal to be hardened is brought against the heating head 27. The container 4 is filled with quenching liquid and the driving device for the eccentric 24 brought into operation, so that the heating head 27 carries out a harmonic motion along the journal to be hardened. If current is now supplied to the transformer, the heating head is brought into

operation, heating the surface layers of the journal to be hardened by high frequency currents.

In a preferable embodiment of the invention a number of heating heads (or halves of heating heads) having apertures 29 of different diameter may be mounted for rotation, so as to achieve adaptability of the device for various diameters of the journals to be hardened.

Obviously the heating head 27 during its harmonic reciprocal movement heats mainly the end portions of the journal; this is however, desirable, because from the end portions heat is being withdrawn by the crank arms.

In order to achieve a uniform heating and uniform hardening of the articles it is sometimes necessary to impart to the heating head 27 movement in accordance with another law than that of harmonic motion. In this case the eccentric 24 is replaced by a suitably shaped cam.

In order to achieve correct centering and movement of the heating head 27, with respect to the heated journal, the heating head is guided directly on the journal. To this purpose, as shown in Fig. 3, the halves or jaw portions 27 of the heating head, which are hollow and cooled by a liquid flowing through them are provided on their surface with a layer of insulating enamel 30, applied on copper, said enamel insulating the heating head with respect to the heated journal. The enamel serves also for securing to the heating head U-shaped gibs 31, preferably made of copper, which abut against the heated journal and are thus guided along the same during the reciprocal movement of the heating head.

A guide of this kind may be arranged also in other ways than disclosed above. Care should, however, be taken to prevent electrical contact between the head and journal. When the journal just heated has been brought to the desired temperature the quenching operation takes place. In the example shown in the drawings this may be accomplished preferably as follows: The aperture 13 is first closed, whereupon the hydraulic or pneumatic mechanism 17, 18 is brought into operation, depressing thus the displacing body 16 into the quenching fluid. The latter consequently rises so as to surround the journal under treatment.

The movement of the heating head 27 continues without interruption so that the quenching liquid around the hardened journal is stirred, while at the same time any steam bubbles, which otherwise would be formed on the hardened journal and interfere with the cooling and hardening operation are safely removed.

A further example of an application of the present invention is the hardening of flat articles, such as gear-teeth. The hardening of gear-teeth, particularly of larger sizes, has heretofore been attended with considerable difficulties.

Fig. 4 shows an individual hardening of gear teeth according to the invention. The teeth 32 of a gear 33, which may be mounted in a way similar to that used in connection with the crankshaft 7 according to Fig. 1, are heated by a suitable heating head 34. The heating head may be broadly similar to the heating head 27 according to Figs. 1 and 2 or 3, but its operative end has to be shaped so as to conform to the shape of the teeth to be hardened. Also in this case it is possible to arrange a plurality of heating heads with different shapes, so as to render the device capable of treating gear teeth of different shapes and sizes. The heating head 34 is mounted on leads 35, similar to the leads 26. The arrangement of the remaining parts may be similar to those according to Fig. 1. During the heating operation the heating head receives reciprocal movement in axial direction in the tooth space. This arrangement permits to achieve the best distribution of heat and the most advantageous course of hardening of the tooth-sides by a suitable formation of the heating head, as in such a case such parts which have to retain their toughness or ductility, need not be hardened.

In this embodiment the heating head enters either from outside or from above the space between two teeth, the sides of which have to be hardened, and after a sufficient heating the quenching operation is carried out as disclosed above. The heating head 34 is then withdrawn from the tooth-space, the gear 33 revolved through the desired angle and the sides of a further tooth-space subjected to treatment.

I claim:

1. In an induction heating apparatus, in combination, a stationary frame; carrier means arranged for movement on said stationary frame; a stationary primary coil; a secondary carried by said carrier means, said secondary together with said primary constituting a transformer for supplying an induced heating current; a heating inductor carried by said carrier means, said heating inductor being of a thickness allowing reciprocation along the length of the part being heated; means for passing an induced current from said secondary to said heating inductor; and drive means for imparting continuously reciprocating movement to said carrier means whereby said heating inductor may be moved along the part to be heated for reciprocation between the two ends thereof, the axial length of one of said coils being less than the axial length of the other of said coils in order to maintain electrical coupling between said primary and secondary coils during the entire period of reciprocation of said carrier means and said secondary coil.

2. In an induction heating apparatus, in combination, a stationary frame; carrier means arranged for movement on said stationary frame; a stationary primary coil; a secondary carried by said carrier means, said secondary together with said primary constituting a transformer for supplying an induced heating current; a heating inductor adapted for reciprocation along the length of the parts being heated; a rigid connection between said secondary and said heating inductor, the said connection supporting said heating inductor and simultaneously supplying an induced current thereto from said secondary; and drive means for imparting continuously reciprocating movement to said carrier means whereby said heating inductor may be moved along the part to be heated for reciprocation between the two ends thereof, the axial length of one of said coils being less than the axial length of the other of said coils in order to maintain electrical coupling between said primary and secondary coils during the entire period of reciprocation of said carrier means and said secondary coil.

3. In an induction heating apparatus, in combination, a stationary frame; carrier means arranged for movement on said stationary frame; a stationary primary coil; a secondary carried by said carrier means, said secondary together with said primary constituting a transformer for supplying an induced heating current; a heating inductor adapted for reciprocation along the length of the parts being heated; said heating inductor comprising a pair of relatively movable

jaw portions adapted to slidably enclose the part to be heated; a rigid connection between said secondary and said heating inductor, said connection supplying an induced current from said secondary to said heating inductor; pivot means provided at the lower end of said rigid connection for permitting operative engagement of said jaw portions about the parts being heated; and drive means for imparting continuously reciprocating movement to said carrier means whereby said heating inductor may be moved along the part to be heated for reciprocation between the two ends thereof, the axial length of one of said coils being less than the axial length of the other of said coils in order to maintain electrical coupling between said primary and secondary coils during the entire period of reciprocation of said carrier means and said secondary coil.

4. In an induction heating apparatus, in combination, a stationary frame; carrier means arranged for movement on said stationary frame; a stationary primary coil; a secondary carried by said carrier means, said secondary together with said primary constituting a transformer for supplying an induced heating current; a heating inductor adapted for reciprocation along the length of the parts being heated; a rigid connection between said secondary and said heating inductor, the said connection supporting said heating inductor and simultaneously supplying an induced current thereto from said secondary; and drive means for imparting continuously reciprocating harmonic movement to said carrier means whereby said heating inductor may be moved along the part to be heated for reciprocation between the two ends thereof, the axial length of one of said coils being less than the axial length of the other of said coils in order to maintain electrical coupling between said primary and secondary coils during the entire period of reciprocation of said carrier means and said secondary coil.

5. In an induction heating apparatus, in combination, a stationary frame; carrier means arranged for movement on said stationary frame; a stationary primary coil; a secondary carried by said carrier means, said secondary together with said primary constituting a transformer for supplying an induced heating current; a heating inductor adapted for reciprocation along the

length of the parts being heated; said heating inductor comprising a pair of relatively movable jaw portions adapted to slidably enclose the part to be heated; a rigid connection between said secondary and said heating inductor, said connection supplying an induced current from said secondary to said heating inductor; pivot means provided at the lower end of said rigid connection for permitting operative engagement of said jaw portions about the parts being heated; and drive means for imparting continuously reciprocating harmonic movement to said carrier means whereby said heating inductor may be moved along the part to be heated for reciprocation between the two ends thereof, the axial length of one of said coils being less than the axial length of the other of said coils in order to maintain electrical coupling between said primary and secondary coils during the entire period of reciprocation of said carrier means and said secondary coil.

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