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2,274,005

METHOD OF AND APPARATUS FOR SURFACE HARDENING METAL ARTICLES

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4 Sheets-Sheet 1

Fig. 1.

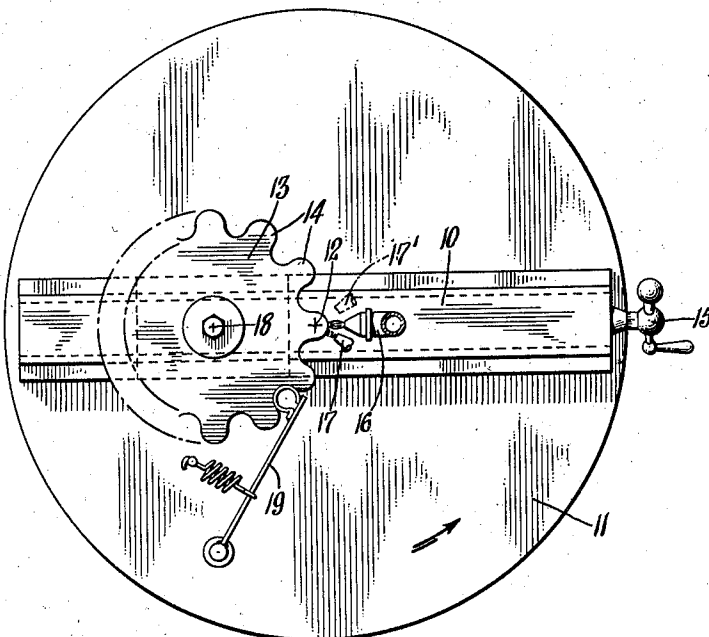
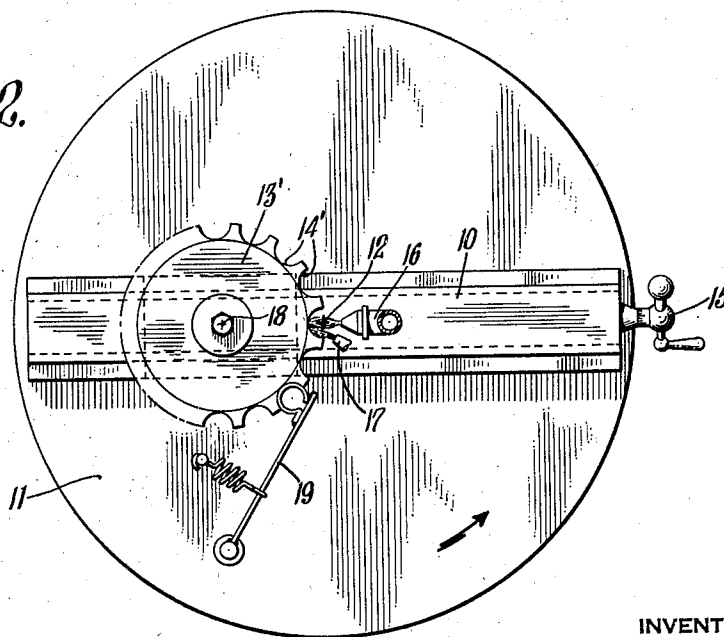


Fig. 2.



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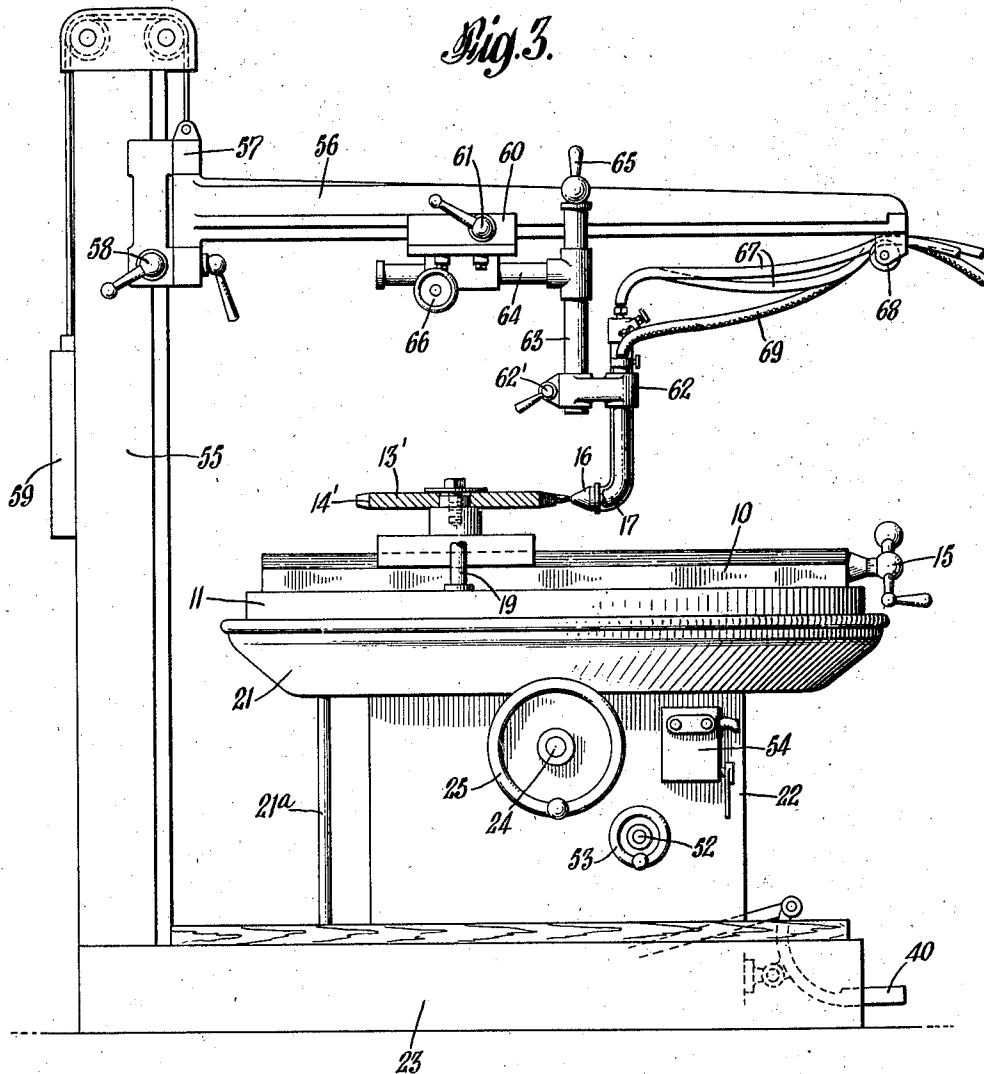
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4 Sheets-Sheet 2



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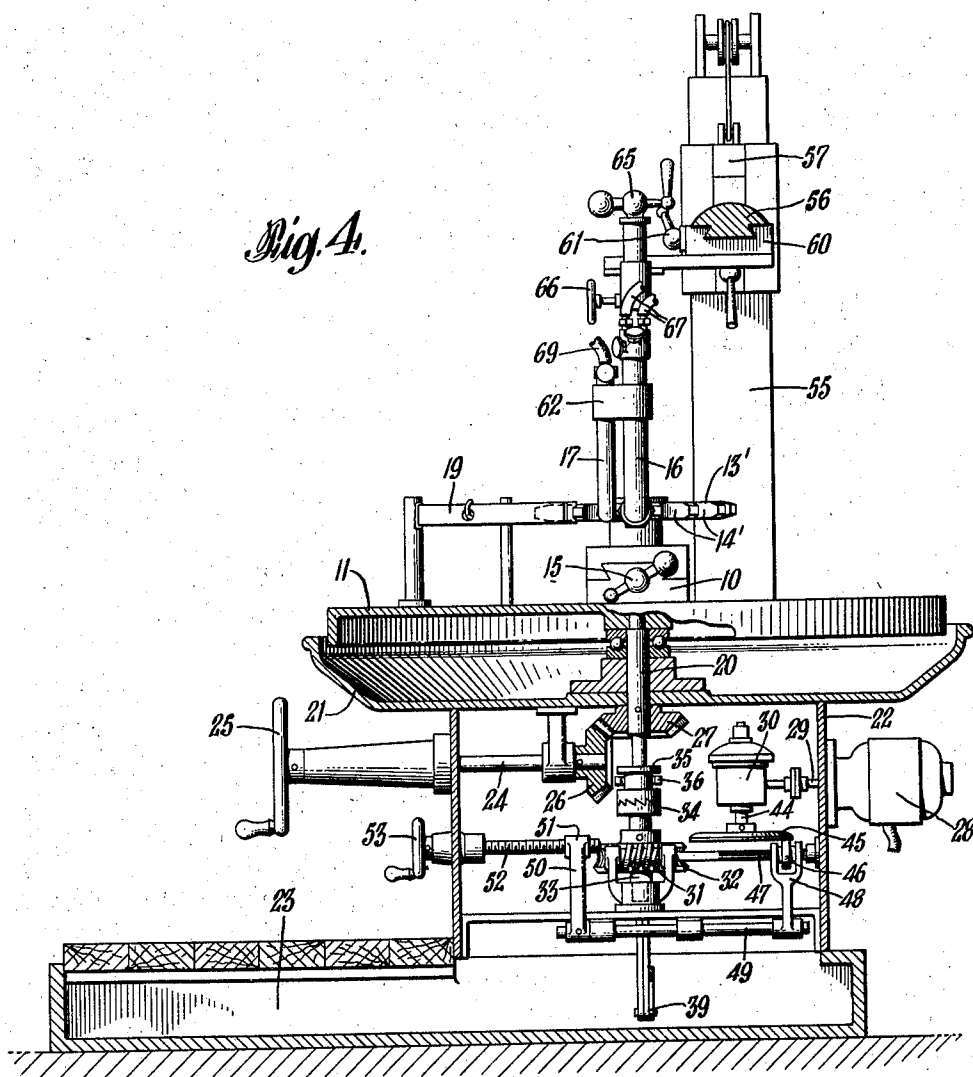
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METHOD OF AND APPARATUS FOR SURFACE HARDENING METAL ARTICLES

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4 Sheets-Sheet 3



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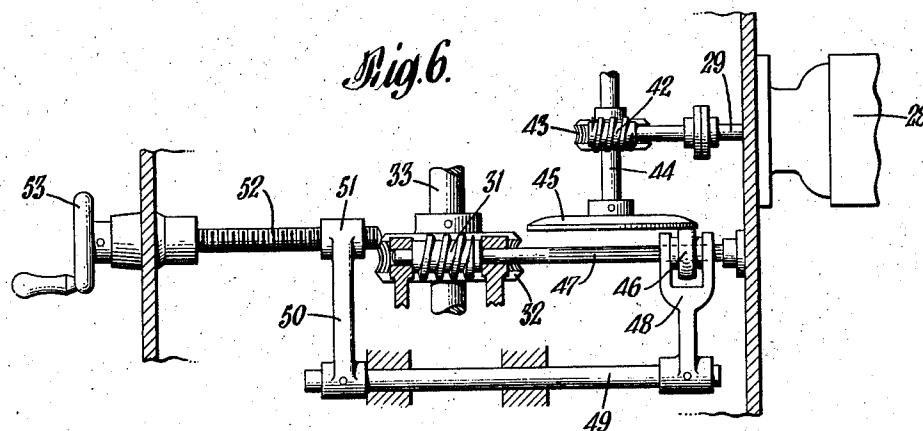
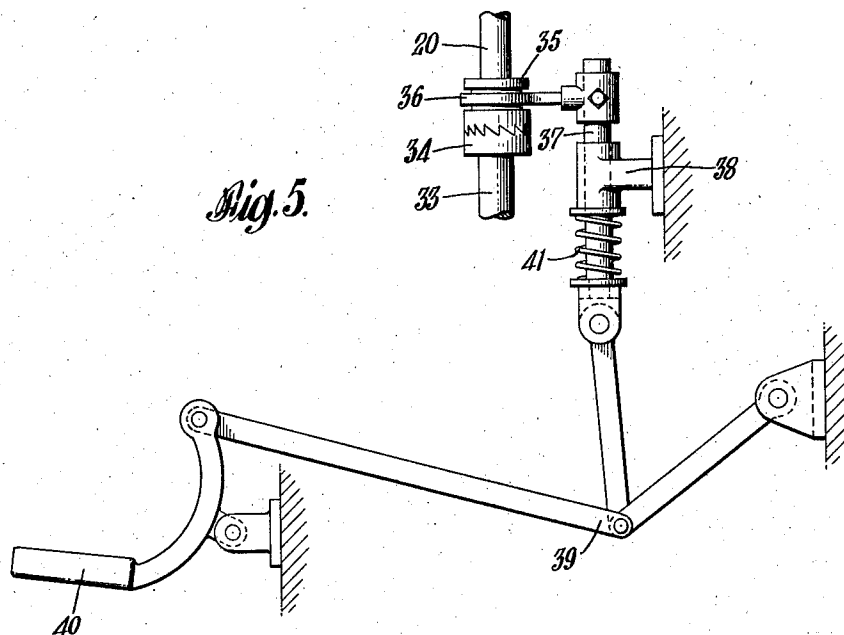
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METHOD OF AND APPARATUS FOR SURFACE HARDENING METAL ARTICLES

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4 Sheets-Sheet 4



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METHOD OF AND APPARATUS FOR SURFACE
HARDENING METAL ARTICLES

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6 Claims. (Cl. 148—19.9)

This invention relates to the surface hardening of metal articles, and more particularly to the hardening of profiled surfaces of metal articles such as plates, cams, sprockets, gears, etc. As used herein "profiled surfaces" refers to eccentric projections, indentations, or similar curved details of plates or cams; or teeth of sprockets or gears, or the like, but not to surfaces of uniformly cylindrical metal articles, such as shafts.

According to prior methods of hardening articles such as gears, a heating flame followed by a quenching medium is directed against successive portions of the width of each tooth of a gear, each tooth being hardened individually and the teeth of the entire gear being hardened in succession. Difficulty is, however, experienced in cases where it is desired to harden the entire side of each gear tooth down to the root, or to harden each tooth across its full width but only over selected portions of the face or flank. (The face of a gear tooth is that portion of the side extending from the top to the pitch circle or pitch line, and the flank of a gear tooth is that portion of the side extending from the pitch circle or pitch line to the root.)

Among the objects of this invention are to provide a novel method of hardening profiled surfaces of metal articles wherein successive portions of the periphery of such articles are treated; to provide a novel method of hardening profiled surfaces of metal articles wherein a plurality of similar details are expeditiously treated; to provide such a method in which a heating medium and quenching medium may be directed against a detail of a profiled surface across the full width thereof; and to provide apparatus 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 diagrammatic plan view of apparatus constructed in accordance with this invention, and arranged for hardening semi-circular projections of a metal article;

Fig. 2 is a diagrammatic plan view of the apparatus of Fig. 1, arranged for hardening semi-circular indentations of a metal article;

Fig. 3 is a side elevation of the apparatus of Figs. 1 and 2;

Fig. 4 is an end elevation, partly in section, of the apparatus of Fig. 3;

Fig. 5 is a partial side elevation showing in greater detail a portion of the apparatus of Figs. 3 and 4; and

Fig. 6 is a partial end elevation showing in greater detail a second portion of the apparatus of Figs. 3 and 4.

According to this invention, successive portions of curved details of a profiled surface of a metal article are treated by effecting a relative rotation between the article and a heating unit, or other suitable source of high temperature heat, about an axis coinciding with the center of curvature of each detail, the distance between the surface of the detail and the heating unit or source of heat being thereby automatically maintained constant. The heating unit is preferably one which is adapted quickly to heat successive portions of the surface of each detail to a temperature at or above the critical range, and in addition, a quenching or cooling unit is preferably associated with the heating unit in such a manner that a quenching and cooling medium is directed against successive heated portions so as to harden the same.

The principles of this invention may be utilized with particular advantage in hardening the teeth of sprockets, where the opposed flanks of adjacent teeth and the root portion joining the two flanks is approximately semi-circular in shape, the center of the semi-circle lying on or being closely adjacent the pitch circle. In such a case, the heating unit is maintained approximately at the center of the semi-circular detail, and the sprocket rotated relatively to the heating unit about an axis coinciding with this center. A uniform distance between the surface of the semi-circular detail and the heating unit is thereby maintained throughout the entire path of traverse.

Apparatus constructed in accordance with the principles of this invention, and particularly adapted to carry out the method of this invention may comprise a rotatable carriage adapted to support the metal article in such a position that the center of curvature of a detail to be hardened may be located co-axially with the axis of rotation of the carriage, a heating unit or device and a suitable support for locating the heating unit in spaced relationship with the surface to be hardened, and suitable means for effecting a relative rotation between the article and the heating unit about the center of curvature of the detail to be hardened. In addition, one or more quenching nozzles or devices may, in the usual manner, be associated with the heating unit.

The rotatable carriage may comprise a machine slide mounted upon and extending dia-

metrically across a horizontal turntable, so that upon placing the metal article upon the machine slide, the center of curvature of a detail to be hardened may readily be brought into coincidence with the axis of rotation of the turntable. For locating the heating unit in spaced relationship with respect to the surface of a detail to be hardened, a bracket overhanging the rotatable carriage and provided with suitable horizontally and vertically adjustable supports may be employed.

More specifically, apparatus utilized in carrying out the method of this invention, as illustrated in Fig. 1, may comprise a machine slide 10 mounted diametrically upon a horizontal turntable 11, which is rotatable about a vertical axis 12. A metal article, such as a gear or sprocket 13, having a plurality of semi-circular projections 14, is placed upon slide 10, with the axis 18 of the gear or sprocket passing through the central longitudinal axis of the slide. The slide is adjusted radially with respect to the turntable by means of a hand wheel 15 so that the center of curvature of one of the semi-circular projections 14 coincides with the axis 12 of turntable 11. A heating burner 16 and associated quenching nozzle 17 are then positioned at a suitable distance from the surface of the detail to be hardened. Upon rotating the turntable 11, in the direction of the arrow of Fig. 1 and through 180° about its axis 12, while maintaining burner 16 and quenching nozzle 17 in fixed position, the entire semi-circular surface of a projection 14 is progressively treated by the heating and quenching devices, and a uniform hardening is effected. When the treatment of one projection has been completed, the article 13 is rotated about its axis 18 to bring another projection into position to be treated. To hold each projection or detail accurately in the correct position with respect to the heating and quenching devices, a spring controlled detent 19 engaging the metal article 13 between two projections 14 spaced from the projection under treatment is utilized.

In Fig. 2, the apparatus of Fig. 1 is shown when utilized in the treatment of a metal article, such as a sprocket 13', having semi-circular depressions 14', the surfaces of which are to be hardened. In this instance, sprocket 13' is adjusted radially with respect to turntable 11 so that the center of curvature of one of the semi-circular depressions 14' coincides with the axis 12 of turntable 11, and the end of the burner nozzle of the heating unit 16 is positioned at axis 12. Rotation of turntable 11, in the direction of the arrow of Fig. 2, will cause the surface of the semi-circular depression to be progressively hardened by the action of burner 16 and quenching nozzle 17.

As shown in Figs. 3 and 4, the machine slide 10 and turntable 11 may be supported by a central vertical spindle 20. Spindle 20 extends downwardly through a circular trough 21, which is adapted to collect the quenching liquid after impingement upon the surface of a detail being hardened, and trough 21 is mounted upon a machine bed 22, which houses the driving mechanism for rotating turntable 11. Trough 21 may be provided with a discharge pipe 21a for carrying the quenching liquid down to a sump 23.

The driving mechanism is designed for optional manual or power-operated drive. For manual operation, a shaft 24 extending through machine bed 22 and provided at its outer end

with a hand wheel 25 is utilized. A bevel gear 26 is secured to shaft 24 at its inner end, and bevel gear 26 meshes with a second bevel gear 27, in turn secured to vertical shaft or spindle 20 in order to effect rotation of turntable 11.

For power-operated drive, a shaft 29 of an electric motor 28, bolted to machine bed 22, is coupled through reduction gearing 30 and a variable speed drive to a worm 31 which engages a worm gear 32. Worm gear 32 is mounted on a vertical stub shaft 33 disposed directly beneath vertical spindle or shaft 20 and stub shaft 33 drives spindle 20 through a dog clutch 34. Parts of the mechanism for disengaging clutch 34 when the manual drive is to be used have been omitted from Fig. 4, for the sake of clarity, but are shown in greater detail in Fig. 5.

Referring now to Fig. 5, the upper half or element of dog clutch 34 is provided with a collar 35, and a fork 36 embraces collar 35. Fork 36 is secured to a vertical shaft 37, disposed alongside spindle 20, and shaft 37 is slidably mounted in a guide bracket 38 secured to the machine bed. Shaft 37 is connected through a toggle linkage system 39 to a foot pedal 40, depression of which serves to disengage clutch 34, while a spring 41 holds clutch 34 in engagement when pedal 40 is not depressed.

The reduction gearing 30 and variable speed drive are illustrated more clearly in Fig. 6. Secured to the end of motor shaft 29 is a worm 42, which engages a worm gear 43 secured to a spring loaded vertical shaft 44, provided at its lower end with a friction disc 45. Friction disc 45 is pressed by the spring loaded shaft 44 into engagement with a friction wheel 46 splined on a shaft 47, worm 31 being mounted on the opposite end of shaft 47. For varying the speed of drive, or for reversing the direction of drive, friction wheel 46 may be moved radially with respect to friction disc 45 along splined shaft 47. To effect such adjustment, a fork 48 which fits over friction wheel 46 is secured to an actuating rod 49, rod 49 being coupled through a link 50 and a screw threaded bearing 51 to a screw 52. Screw 52 is provided with a hand wheel 53, which may be conveniently located close to hand wheel 25, as illustrated more clearly in Fig. 3, and a switch 54 for controlling motor 28 may also be conveniently mounted on machine bed 22 alongside hand wheels 25 and 53.

For readily locating the heating and quenching devices with respect to the surface of a detail to be hardened, a vertical supporting pillar 55 carrying a horizontal arm 56 is disposed alongside the machine bed. The arm 56 is pivotally mounted for movement in a horizontal plane in a bracket 57, bracket 57 being slidably mounted on pillar 55, and a clamp 58 being adapted to secure bracket 57 in any desired position. A weight 59 balances arm 56, to insure easy vertical adjustment of bracket 57 and arm 56.

A carriage 60 is slidably mounted on arm 56, and a clamp 61 is utilized in locking carriage 60 in any desired horizontal position. One end of a bracket 62 is secured to heating unit 16, and the other end of bracket 62 is rotatably mounted on a vertically adjustable shaft 63, a clamp 62' being provided to permit bracket 62 to be locked in any desired radial position on shaft 63. Vertical shaft 63 is slidably mounted at the end of a horizontal bar 64, in turn slidably mounted on carriage 60. Relatively fine adjustment of the position of the heating unit and shaft 63 in a vertical direction may be effected by a control

handle 65, while relatively fine adjustment of the heating unit and bar 64 in a horizontal direction may be effected by a hand wheel 66. Flexible conduits 67 for supplying suitable gases to heating unit 16 are carried over a guide pulley 68 mounted on the end of arm 56, and are connected with a suitable source or sources of supply of a combustible gas and a combustion supporting gas, such as acetylene and oxygen. One or more quenching nozzles, such as quenching nozzle 17 of Figs. 1 and 2, may be provided alongside the heating unit and secured thereto or to bracket 62, as shown, and a flexible conduit 69 for supplying a quenching medium to the nozzle or nozzles may also be carried over guide pulley 68.

After the metal article having details to be hardened, such as a sprocket 13, is mounted on machine slide 10 in such a manner that the center of curvature of the detail coincides with the axis of turntable 11, the heating unit and associated quenching nozzles are placed in the desired proximity to the surface of the detail to be hardened by adjustment of control handle 65 and hand wheel 66. Motor 28 is then started so that turntable 11 will be rotated and the curved surface of the detail to be hardened will thereupon be progressively hardened by the heating and quenching units while the latter remain at a uniform distance from the surface.

Rotation of turntable 11 and the metal article through 180° will provide for the treatment of one semi-circular detail, so that after the turntable has rotated through this angle, the motor 28 may be stopped and the article moved about its own axis through the space of one detail or tooth, the hardening operation then being repeated. To avoid the necessity of bringing the turntable back to its initial position before commencing the treatment of a succeeding detail in cases where such details are identical with one another, the direction of rotation of spindle 20 may be reversed by moving friction wheel 46 to the other side of the center of disc 45 by hand wheel 53. During rotation of spindle 20 and the metal article in such reverse direction, to effect quenching, nozzle 17 should be positioned on the opposite side of heating burner 16, as at 17' in Fig. 1, or a second quenching nozzle provided on the opposite side of burner 16.

The heating unit used, of course, should cover the full width of the surface to be hardened.

Where the surface of the detail to be hardened does not constitute part of a smooth circle, such as a gear tooth, whose surface normally corresponds to a portion of an involute curve, there will be no exact center of curvature of the detail. In such a case, the article is so placed that the axis of turntable 11 coincides with an approximate center of curvature of the detail, i. e., that point most nearly equidistant from all points on the curve of the surface. But even when axis 12 coincides with such an approximate center of curvature, all points on the surface will not be located equidistantly from axis 12. Consequently, as turntable 11 rotates, the heating medium will not be directed normally against the surface of any such details, which are eccentric. However, the heating unit 16 is, as previously described, rotatably mounted on vertical shaft 63, the longitudinal axis of shaft 63 preferably passing through the end of the nozzle of heating unit 16. By suitably rotating bracket 62 about shaft 63 during treatment, the application of the heating flame may be maintained normal to the surface being treated without changing the dis-

tance between the heating unit and the surface. Rotation of bracket 62 may be effected manually, or may be effected automatically in any suitable manner. When treating details which correspond in shape to a portion of a circle, such as semi-circular projections or indentations, the necessity for rotating bracket 62 and heating unit 16 of course does not arise, and in such instances bracket 62 may be locked on shaft 63 by clamp 62' after initial positioning.

Should it be desired to harden only a portion of a curved surface, suitable mechanism may be provided for disconnecting the supply of gases to the heating unit while those portions which are to remain unhardened are traversed by the heating unit.

In order to re-use the quenching liquid in case such is desirable, suitable means may be provided in connection with sump 23 in order to convey the liquid back to the quenching nozzles. Such means may conveniently be operated by motor 28.

Suitable mechanism may be provided to stop motor 28 as soon as a detail to be hardened has been treated, and such mechanism may also be coupled with suitable means for controlling the flow of gases to the heating unit so that the application of the heating medium may be terminated simultaneously with the stopping of the motor.

It will be understood that the apparatus may be so constructed that the article to be treated may be mounted for rotation about a horizontal axis instead of a vertical axis, or about an axis inclined at any other convenient angle. It also will be understood that the heating medium may be not only a combustible mixture of gases, such as oxygen and acetylene, but also any other suitable type of heating medium adapted to heat successive portions of a detail to be hardened. It will be further understood that various other changes may be made which will not depart from the spirit and scope of this invention.

What is claimed is:

1. A method of surface hardening a plurality of curved peripheral details of a profiled surface of a metal article, all of said details lying substantially in the same plane and each of said details conforming substantially to a portion of a circle of revolution with the axes of said details located substantially equi-distantly from a common center disposed in said plane, such method comprising mounting the article with an axis of rotation extending through said common center, and also with a second axis of rotation extending through the axis of revolution of one of said details; positioning a source of high temperature heat in relatively fixed position and in operative relation with respect to the detail whose axis coincides with the second center of rotation; effecting rotation of said article about said second center so as to heat successive surface portions of said detail; effecting rotation of said article about said axis extending through said common center, so as to place a second detail in such a position that its axis will coincide with said second center of rotation; effecting rotation of said article about said second axis so as to heat successive surface portions of said second detail; and intermittently rotating said article about said common center and about said second center so as to treat successive details in a similar manner while maintaining said source of high temperature heat in relatively fixed position.

2. A method of hardening a plurality of curved details of a profiled surface of a metal article; in

which high temperature heat is applied to the surface of each detail so as to heat the same to a temperature at or above the critical range, such method comprising directing a high temperature heating medium substantially normally against the surface of one of said details; during the application of heat effecting rotation of said metal article about an axis coinciding with the approximate center of curvature of the detail being hardened; rotating said article about its own axis so as to place a second detail in position for treatment; rotating said article about an axis coinciding with the approximate center of curvature of said second detail, but in a direction opposite to that in which rotation was effected during the treatment of the first detail hardened; and similarly rotating said body about its own axis and then about an axis coinciding with the approximate center of curvature of each subsequent detail to be hardened.

3. A method of hardening in succession a plurality of similar curved details of a profiled surface of a metal article, each of such details having a center or approximate center of curvature located at substantially the same distance from the axis of said article, such method comprising mounting said article for rotation about its own axis and also for rotation about a second axis coinciding with the center or approximate center of curvature of a detail to be hardened; intermittently rotating said article about its own axis to cause the center or approximate center of curvature of successive details to coincide with said second axis; mounting a heating and quenching unit in spaced operative relationship with respect to a detail whose center or approximate center of curvature coincides with said second axis; intermittently rotating said article about said second axis; and maintaining said heating and quenching unit in a relatively fixed position during such intermittent rotation of said article, both about its own axis and about said second axis.

4. Apparatus for hardening a plurality of curved details of a profiled surface of a metal article, each of such details conforming substantially to a portion of a circle of revolution and the axes of such circles of revolution being located substantially equi-distantly from a common center, said apparatus comprising a rotatable carriage provided with means for supporting the metal article in such a position that the center of curvature of a detail to be hardened

coincides with the axis of rotation of the carriage; means for reversing the direction of rotation of said carriage; means for supporting a heating unit in spaced relationship with respect to the surface of the detail to be hardened; means for effecting a relative rotation between the article and said heating unit about the center of curvature of such detail so as to heat successive portions of said surface and maintain said heating unit at a uniform distance from the surface during such heating; and means for effecting a relative rotation between said article and said heating unit about said common center so as to place successive details to be hardened in spaced relationship with respect to said heating unit.

5. Apparatus for hardening in succession a plurality of curved details of a profiled surface of a metal article, such details having only an approximate center of curvature, such apparatus comprising, in combination, a rotatable carriage; means adjustable radially with respect to the axis of rotation of said carriage for rotatably supporting said article on said carriage; means for supporting a heating unit in spaced relationship with respect to the surface of a detail to be hardened; means for rotating said carriage so as to effect a relative rotation between the article and the heating unit in order to cause successive portions of the surface of a detail being treated to be heated, said heating unit being rotatably mounted so as to permit a heating medium to be directed normally against the surface during the application of heat without substantial alteration in the distance between the surface and the heating unit; and means for registering in succession each of such details to be hardened in operative position with respect to said heating unit and with the approximate center of curvature of each detail so registered coinciding with the axis of rotation of said carriage.

6. Apparatus for hardening a curved detail of a profiled surface of a metal article, comprising a rotatable carriage; means adjustable radially with respect to the axis of rotation of said carriage for rotatably supporting said article on said carriage; means for rotating said carriage; means for reversing the direction of rotation of said carriage; means for applying high temperature heat to the surface of a detail to be hardened; and means for supporting said heating means in operative relation with respect to the surface to be hardened.

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