Oct. 4, 1949. A. E. SHORTER 2,483,477

SURFACE HARDENING OF FERROUS METAL ARTICLES

Filed Nov. 30, 1943 4 Sheets-Sheet 1

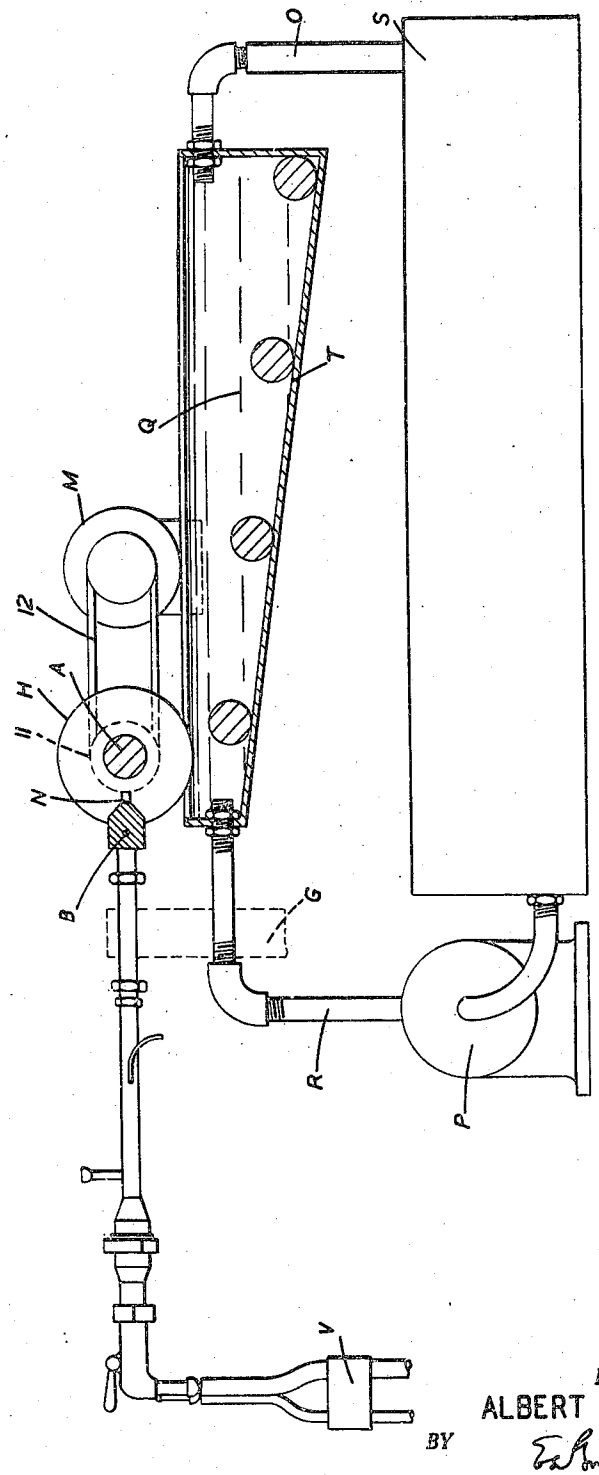

FIG. 1.

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Filed Nov. 30, 1943 4 Sheets-Sheet 2

FIG.2.

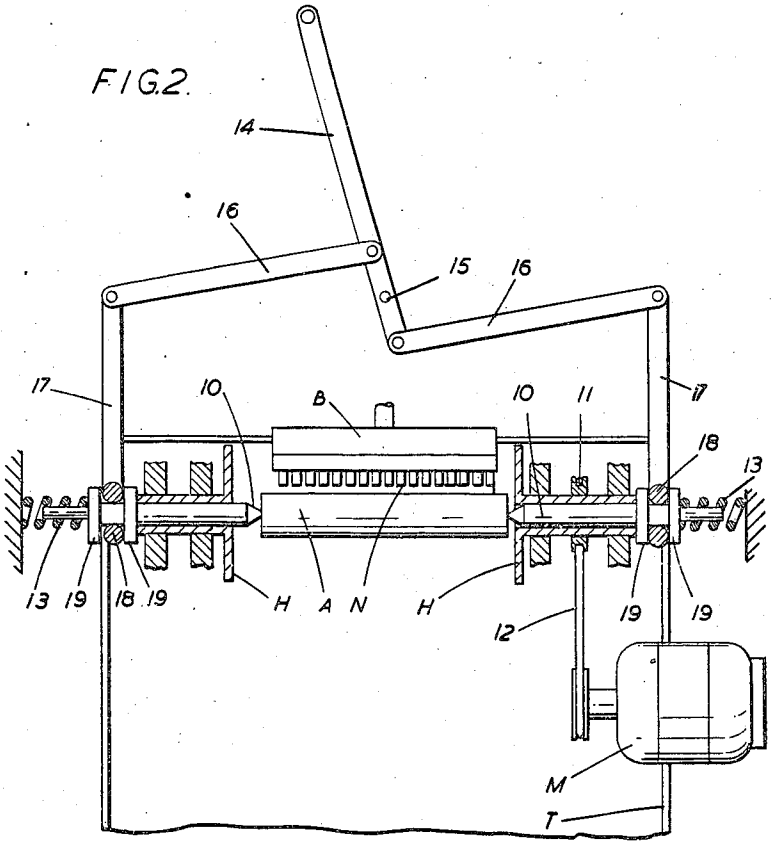
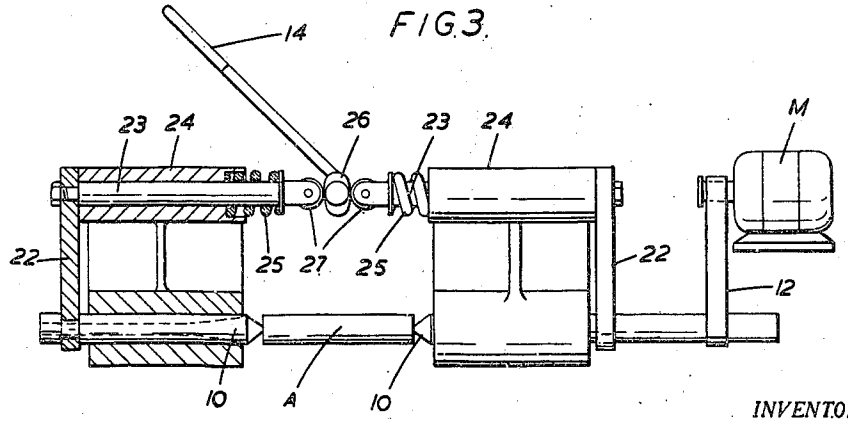


FIG.3.



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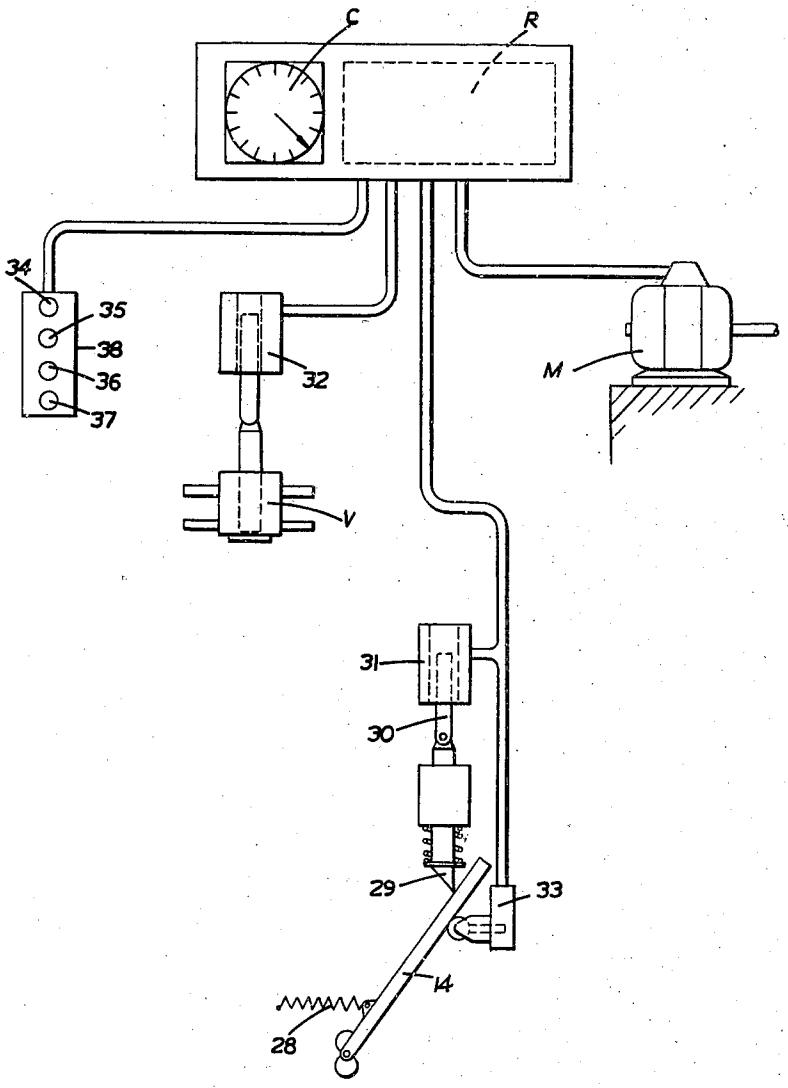
SURFACE HARDENING OF FERROUS METAL ARTICLES

Filed Nov. 30, 1943 4 Sheets-Sheet 3

FIG.4.



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SURFACE HARDENING OF FERROUS METAL ARTICLES

Filed Nov. 30, 1943 4 Sheets-Sheet 4

FIG.5.

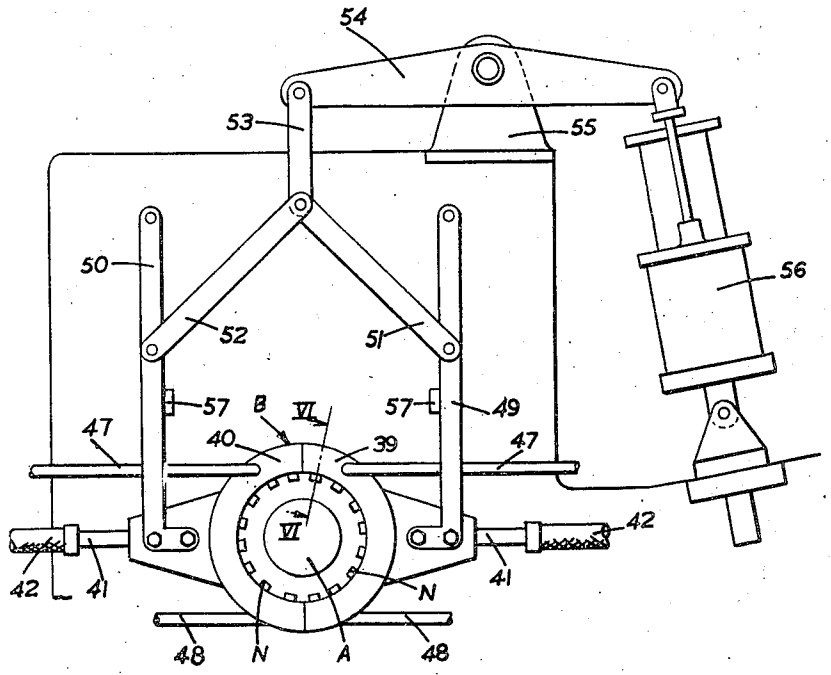
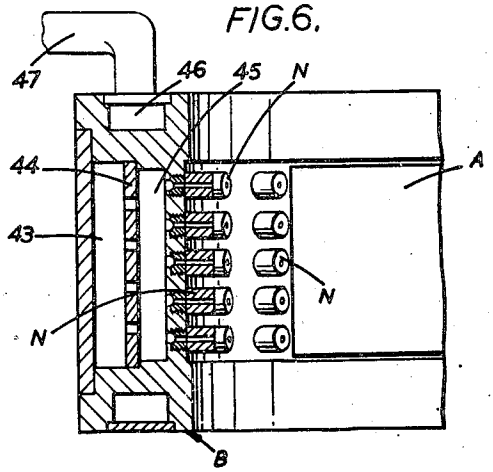


FIG.6.



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SURFACE HARDENING OF FERROUS METAL ARTICLES

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4 Claims. (Cl. 148—21.56)

1

The present invention relates to the surface hardening of ferrous metal articles. More particularly the invention deals with the surface hardening of ferrous metal articles having substantially cylindrical surfaces, such as gudgeon pins, spindles or bars.

It is well known that by heating a ferrous metal article to the critical point or above and quenching the article when at this temperature increased hardness may be imparted to the surface layer. To prevent cracking or uneven wear of the hardened surface when the article is in service, not only is it essential that the surface be uniformly heated, but also that it be rapidly and uniformly quenched. The mere immersion of the heated article in a quenching bath has been found to produce a surface which is not fully hardened, due probably to the formation of a low conductivity layer of steam or vapour around the heated surface, which prevents rapid chilling thereof. Also, if the heated article be dropped into a bath of quenching liquid, it has been found that narrow zones of reduced hardness are formed where the article rests on the bottom of the bath.

With a view to imparting uniform hardness to the whole or part of a surface of revolution, it has been proposed to mount the article to be treated in a holder adapted to rotate the article about the axis of revolution, to apply high temperature heat to the surface and then to quench the heated surface, the article being retained in the holder during the quenching operation. In consequence, the heating of another article cannot proceed until the quenching of the previous article has been completed thereby entailing loss of time.

It is an object of this invention to effect in a simple and inexpensive manner the thorough and uniform quenching of each of a succession of heated articles with minimum interruption of the successive heating periods.

According to this invention a surface or a part surface of an article is hardened by heating the surface or part surface at least to the critical temperature, and whilst at this temperature immersing the article in a stream of quenching liquid discharging substantially horizontally into a quenching tank in a direction and with sufficient velocity to cause the article to be tumbled in the stream and pushed toward the point of removal of the quenched article from said tank whereby any retarding of the quench due to the formation on the heated surface of a layer of low thermal conductivity steam or vapour is substantially prevented and also whereby a narrow surface zone of reduced hardness, which would result due to the heated article remaining at rest when dropped into the quenching tank, is substantially prevented.

2

The preferred heat treating method comprises mounting the article over a stream of quenching liquid, heating the article when so mounted to at least the critical temperature and then releasing the article so that it drops freely and vertically into the stream of quenching liquid.

Apparatus for surface hardening by the foregoing methods may comprise in combination a channel and means for supplying a stream of quenching liquid thereto, a holder for supporting an article whilst it is being heated, and means for releasing the heated article from said holder to drop into the stream of quenching liquid discharging substantially horizontally into said channel. The channel may be constituted by chute or tank having its bottom surface inclined downwardly from the horizontal, the chute or tank having side walls of sufficient height to retain therebetween an adequate depth of liquid in order completely to immerce the heated article as it is tumbled and propelled along the chute or tank in the quenching stream.

The article may be heated either by means of a heating unit supplied with a combustible gas, such as an oxy-acetylene or oxy-coal gas mixture, or by means of a heating unit supplied with electric current and adapted to operate inductively, resistively or through an arc. Relative motion may be effected between the heating unit and the article so that heat is directed uniformly over the whole surface to be hardened.

The heating unit may be of annular shape and adapted to embrace the article so that heat is directed radially upon the article at a plurality of circumferentially disposed points. To permit the article to drop into the quenching stream when an annular heating unit is used, the unit may comprise at least two sectors, means being provided for moving out of the way the sector or sectors which would otherwise prevent the article from dropping freely and vertically into the quenching stream when it is released from the holder.

Apparatus for surface hardening cylindrical articles, such as gudgeon pins, spindles or bars, in accordance with this invention, are shown by way of example in the accompanying drawings in which:

Fig. 1 is a view in side elevation, partly in section, showing a complete machine including a

holder for the articles to be heated, one such article being shown mounted in the holder;

Fig. 2 is a plan, partly in section, of one form of article holder with automatic release mechanism;

Fig. 3 shows in section an alternative form of automatic release mechanism;

Fig. 4 is a schematic arrangement of an automatic control system;

Fig. 5 is a view in elevation of an annular heating unit and associated equipment, and

Fig. 6 is an enlarged part section of the heating unit on the line VI—VI of Fig. 5.

Referring to Fig. 1, the apparatus comprises a heating unit B for directing high temperature heat upon the article. In the example chosen, the heating unit is shown to be a gas burner with a row of nozzles N and having a gas control valve V. The burner B is held in an adjustable clamp G, shown diagrammatically, by means of which the position of the burner may be adjusted, so that the heating medium is directed upon the surface of an article A to be treated, the article being mounted in a holder H located above the shallow end of a tank T supplied with quenching liquid Q. To enable the work to be rotated during the heating period, the holder H may be coupled to a driving motor M which may conveniently be mounted on a side wall of tank T. The bottom of tank T is inclined to the horizontal as shown, and an overflow pipe O for the quenching liquid Q leads from the deep end of the tank T to a sump S whence the liquid is returned to the tank T by means of a pump P and return pipe R arranged to deliver a copious stream of the quenching liquid to the shallow end of the tank T. The delivery end of pipe R is arranged, as shown, to feed the quenching liquid to the tank in the longitudinal direction, that is to say down the sloping bottom from the shallow end towards the deep end. The depth of the tank T and the connection from the tank to the overflow pipe O are preferably such that the article A, when dropped into the tank, can be wholly immersed in the quenching liquid even at the shallow end.

In operation, an article A is mounted in the holder H, the supply of heating medium is turned on, and when the surface of the article has attained the critical temperature the article is released from the holder H and drops into the tank T, along the bottom of which it is tumbled, the movement being accelerated by the substantially horizontal stream of quenching liquid delivered through pipe R, which is preferably of sufficient velocity to cause considerable turbulence in the tank. By this means the heated surface is thoroughly and uniformly quenched in a simple and inexpensive manner. By the time the article reaches the deep end of the tank T the quenching operation is complete and the article can be removed. As soon as the article has dropped out of the holder H another article can be inserted in the holder and the heating operation can thereby be carried on without the loss of time hitherto incurred by carrying out the quenching operation whilst the article is retained in the holder.

A holder suitable for mounting the articles and rotating them about a horizontal axis during the heating period is shown in detail in Fig. 2, to which reference will now be made.

The holder comprises a pair of movable lathe centres 10, one of which is associated with an eccentric driving pin (not shown) adapted to engage a recess formed in an end of the article to provide a driving torque. One of the lathe

centres 10 is provided with a driving pulley 11 coupled through a belt 12 to the motor M, mounted as aforesaid on the side of the tank T.

The two lathe centres urged towards one another by springs 13 and away from one another by means of a lever 14 are movable about a pivot 15 and coupled through links 16 to the ends of pivoted arms 17, the further extremities of which are provided with forks 18 engaging collars 19 secured to the lathe centres 10. On moving the lever 14 about its pivot 15, the centres are simultaneously moved apart horizontally to release the article A which drops freely and vertically and without tilting into the tank T thereby ensuring substantially instantaneous immersion of the whole article in the quenching liquid.

Fig. 3 shows an alternative form of holder, where equivalent parts bear the same reference numerals as in Fig. 2. The two centres 10 extend respectively through the head-stock 20 and tail-stock 21 of a lathe and are coupled through arms 22 to push rods 23 movable in guides 24. Springs 25 embracing the push rods 23 urge these two members and consequently the centres 10 towards one another. A double cam 26 coupled to an operating lever 14 is arranged to bear against rollers 27 mounted on the opposed extremities of the push rods 23. On moving lever 14 in the clockwise direction through an angle of about 90°, the cam 26 is rotated to thrust the push rods 23 apart, simultaneously moving the centres 10 apart to release the article A.

Whilst the apparatus above described is capable of manual operation, it is of advantage from the points of view of speed of operation and uniformity of product, to carry out the process in an automatic manner. A control system for automatic operation is shown in Fig. 4.

The lever 14 operable to release the article as above described is shown in Fig. 4 in the loaded position, that is to say, with an article held in place between the centres. The lever 14 is provided with a spring 28 urging the lever 14 to the release position, whilst a detent 29 is arranged to hold the lever 14 in the loaded position, detent 29 being coupled to the plunger 30 of a solenoid 31 which, when energised, moves the plunger 30 to withdraw the detent 29 from engagement with lever 14 which thereupon moves under the action of spring 28 to the released position.

Solenoid 31 is periodically energized by the operation of a relay in a relay panel R controlled by means of a timing mechanism C. The latter also controls through further relays in panel R the energization of a solenoid 32 adapted to turn on and off the gas valve V and the energisation of the motor M which, as aforesaid, rotates the article to be treated. The timing mechanism C is set in operation by means of a limit switch 33 which is closed by lever 14 as it moves into the loaded position.

The system, which may conveniently be connected to the electric supply mains through a push button starter switch 34, operates as follows:

The hand of the timing mechanism C is pre-set to give the required heating period and pump P is started up, the pump being driven by any convenient source of motive power. The article is mounted in the holder and lever 14 is moved to the loaded position to retain the article between the centres. As lever 14 assumes the loaded position where it is held by detent 29, it simultaneously effects the closure of limit switch 33. Starter button 34 is depressed whereupon the

hand of timing mechanism C commences to rotate from the pre-set position to zero whilst simultaneously relays in relay panel R are closed, causing both the energisation of gas valve solenoid 32 to open the gas valves V and the starting of motor M. A pilot light may be provided to ignite the gas jets issuing from the burner and the heating continues with rotation of the article until the hand of the timing mechanism C returns to zero position. At this instant release solenoid 31 is momentarily energised to cause the withdrawal of detent 29 from engagement with lever 14. The latter moves under the action of spring 28 to the unloaded position thereby releasing the article from holder H and the article drops into tank T to be thoroughly and uniformly quenched in the stream of water supplied by pump P. Simultaneously with the momentary energisation of the release solenoid 31 to cause withdrawal of the detent 29, the gas valve solenoid 32 is de-energised to turn off the gas valves V and the motor M is stopped. The hand of timing mechanism C automatically returns to its pre-set position under the action of a spring, a fresh article is mounted in the holder and retained therein by moving lever 14 by hand to the loaded position with consequent closure of limit switch 33. Push button 34 is then again pressed and the cycle of operations is repeated. In this manner the thorough and uniform quenching of each of a succession of heated articles may be carried out with minimum interruption of the heating periods.

For purpose of testing the gas supply to the burner, a test button switch 35 may be provided which is arranged to cause the energisation of solenoid 32 independently of the operation of other parts of the system. In addition, further push buttons 36, 37 may be provided for independent starting and stopping of motor M. The push buttons 34, 35, 36, 37 may be mounted on a panel 38 secured to the tank T or other remote point readily accessible to the operator.

As shown in Figs. 1 and 2 the burner B has a single row of nozzles N substantially co-extensive with the length of the surface to be heated, the end nozzles being preferably located slightly short of the end of the article to prevent overheating of the edges, these being heated by conduction from adjacent zones. In order to achieve more uniform and rapid heating, it may be of advantage to employ an annular type of heating unit. A heating unit of this type is shown in Figs. 5 and 6 and will now be described.

The heating unit comprises a burner B formed of two semi-cylindrical elements 39, 40, each element having several rows of nozzles N directed radially towards the article A to be heated. As shown in Fig. 6 each row consists of five nozzles, the length of the rows being slightly shorter than the length of the article to prevent overheating of the edges. Each element 39, 40 is provided with a gas tube 41 adapted to be coupled to a flexible hose 42 leading through control valves (not shown) to a source of gas supply under pressure. Gas tube 41 delivers into a header 43 communicating through an apertured partition 44 with a distribution chamber 45 from which gas is discharged through the nozzles N to produce rows of uniform jets. Each element 39, 40 is furnished with a cooling chamber 46 to which a coolant can be admitted through conduit 47 and discharged through conduit 48.

To permit the article to drop into the quenching stream at the end of the heating period, the

two elements 39, 40, are hingedly mounted respectively on arms 49, 50 coupled through links 51, 52 to a common actuating member 53 so as to form a toggle mechanism. Member 53 is mounted on a pivot at one end of a lever 54 supported centrally in a bracket 55 and coupled at its further extremity to a thrust device 56 such as an electrically operable thruster of a type known per se.

In operation, on completion of each heating period the thrust device 56 is energised to impart a thrust to the toggle mechanism causing the two elements 39, 40 to move apart and permit the heated article, as it is released from the holder, to drop into the quenching stream. The periodic energisation of the thrust device 56 may be controlled through a further relay in panel R (Fig. 4) so as to take place automatically upon termination of each heating period.

In order to ensure that the burner elements are centrally located with respect to the work on returning to the heating position for treating a fresh article, stops 57 may be provided for locating the arms 49, 50.

It will be appreciated that the toggle mechanism described above is given by way of example only and that a variety of alternative means may be adopted for moving the heating unit so as to give an uninterrupted passage to the heated article as it is released from the holder. Moreover, it will be understood that an electrical heater could be used instead of the burner herein described.

I claim:

1. In a method of heat treating a ferrous metal article wherein heat is applied to at least a portion of said article while the article is supported by a holder, the step of quenching such heated article which comprises dropping the heated article vertically and freely from said holder into a stream of quenching liquid discharging substantially horizontally into and lengthwise of the bottom of a tank toward the point of removal of the quenched article from said tank and at a velocity sufficient to tumble said article within said tank and to push said article toward said point of removal.

2. A method of hardening a surface or at least a portion of a surface of a ferrous metal article wherein such surface or a portion thereof is heated to at least the critical temperature while said article is releasably mounted in a holder, the quenching step which comprises discharging a stream of quenching liquid substantially horizontally into a tank lengthwise of the bottom of the said tank toward the point of removal of the quenched article from said tank and along a path vertically below said holder, and releasing such heated article to permit it to drop freely and vertically from said holder into such substantially horizontal stream of quenching liquid, and maintaining said stream at a velocity sufficient to tumble said article in said stream.

3. In a heat treating apparatus having heating means for heating at least a portion of a cylindrical surface of a cylindrical metal article, and a tank adapted to contain a quenching medium into which the heated article is dropped, the combination therewith of the improvement which includes holder means vertically above said tank for releasably supporting such cylindrical article while it is being heated, said holder means comprising a pair of horizontally coaxial devices horizontally movable toward each other to releasably

engage the opposite ends of a cylindrical article to support said article with its principal axis in a horizontal position while the article is being heated, and means for simultaneously moving both of said devices horizontally and apart, to simultaneously disengage them from a heated article to release the same and thereby permit the heated article to drop without tilting and vertically from said holder means into a quenching medium in said tank.

4. In a heat treating apparatus having holder means for releasably supporting a metal article so that its principal axis is disposed horizontally, a tank vertically below said holder means and adapted to contain a quenching medium, and means operable to release a heated article from said holder means to fall vertically into a quenching medium in said tank, the combination therewith of the improvement which includes annular heating means for applying heat to a surface of an article so supported by said holder means, said heating means being constructed and arranged to embrace such article while heating the same and comprising at least two relatively movable sectors, and means operable to move out of the way the sector or sectors which otherwise would prevent

a released heated article from falling vertically and freely from said holder means into a quenching medium in said tank.

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