

Sept. 30, 1947.

D. K. FERRIS

2,428,068

METALLURGICAL APPARATUS

Filed March 22, 1943

3 Sheets-Sheet 1

Fig. 2

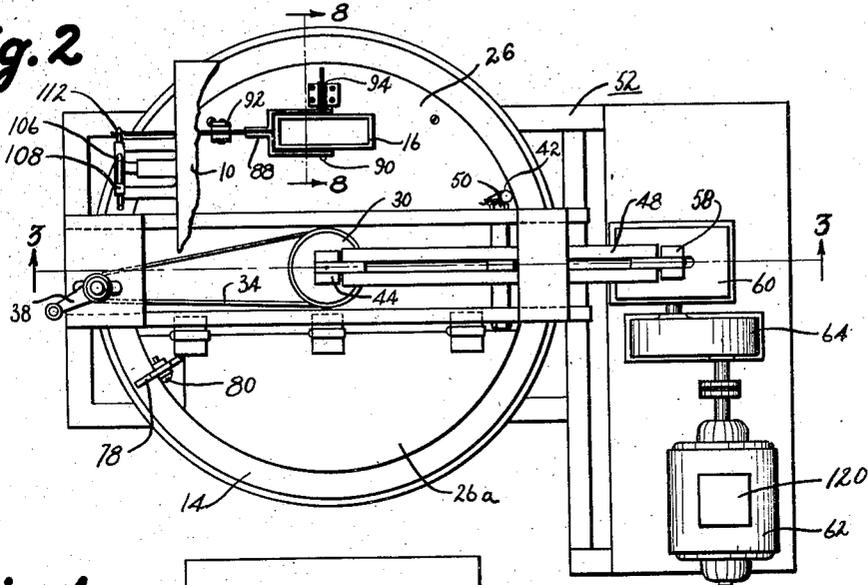
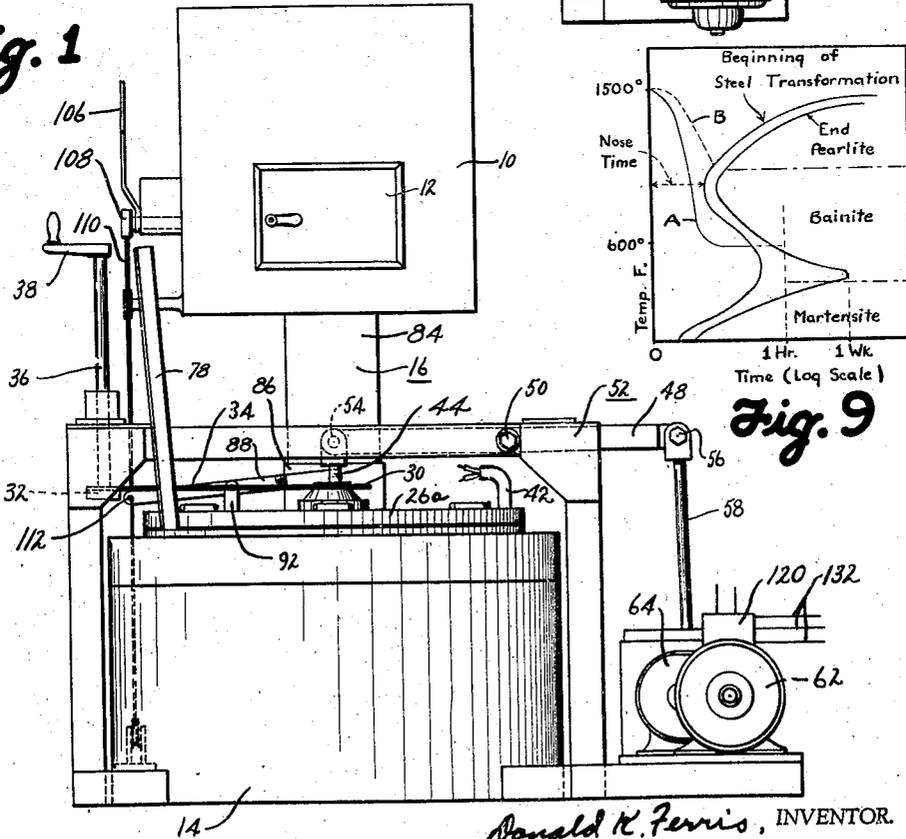


Fig. 1



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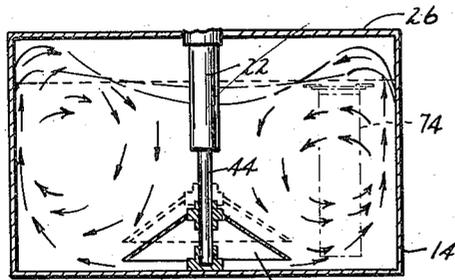


Fig. 6

Fig. 4

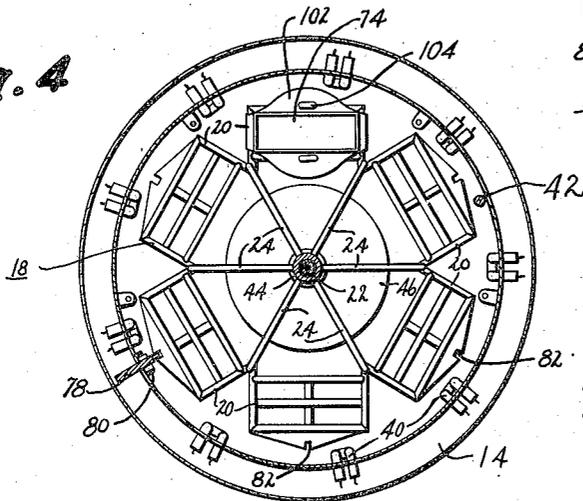


Fig. 3

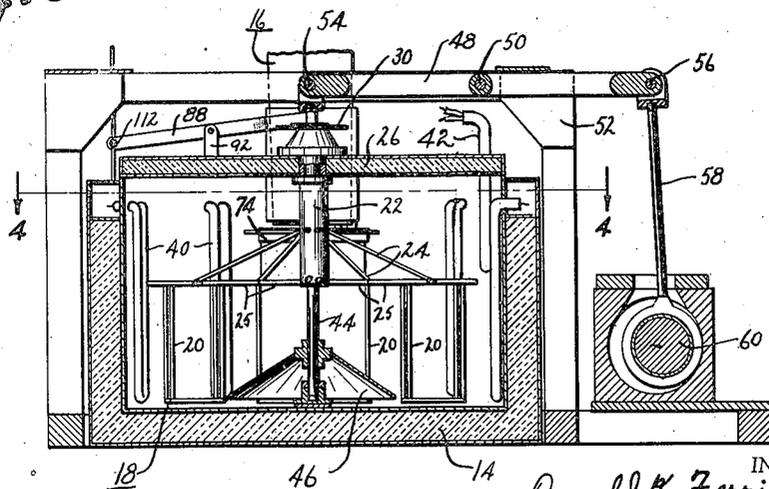
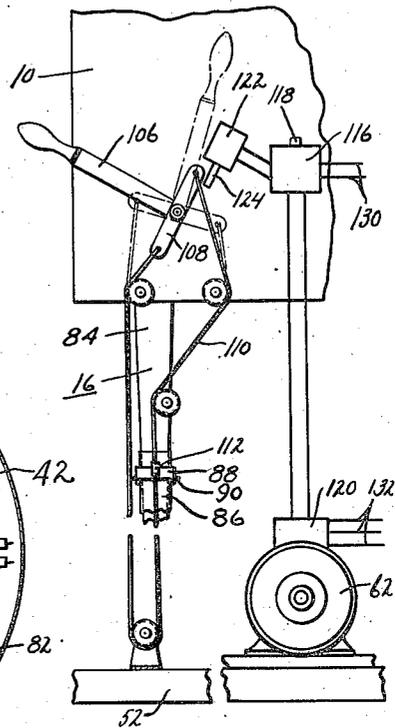


Fig. 5



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3 Sheets-Sheet 3

Fig. 7

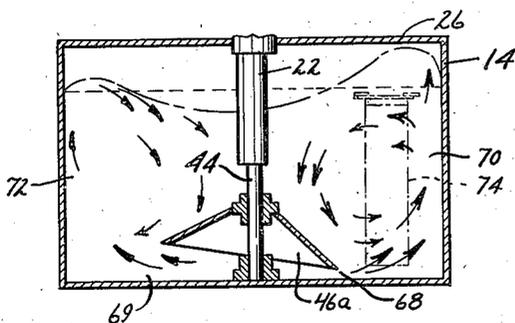
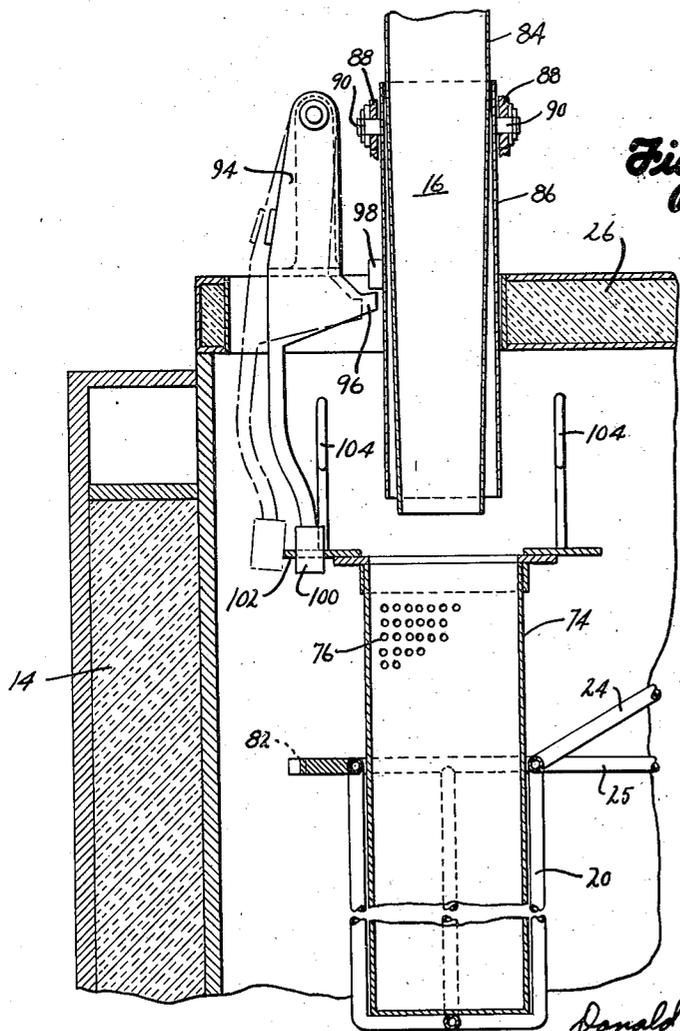


Fig. 8



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# UNITED STATES PATENT OFFICE

2,428,068

## METALLURGICAL APPARATUS

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5 Claims. (Cl. 266-4)

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This invention relates to metallurgical method and apparatus and more particularly to the thermal hardening of steels, alloys and the like in which the hardening is obtained by reason of the phenomenon of compound particle solution and subsequent precipitation in the metal at the various appropriate temperatures so as to produce a bainite crystal structure.

One object of the present invention is to provide an improved thermally hardened carbon or alloy steel product.

Another object of the present invention is to provide apparatus for thermally hardening masses of small articles such as latches, bolts, nuts, springs, and the like.

This invention constitutes an improvement over the now well-known method and apparatus set forth in the patent to Bain et al., 1,924,099. The process and apparatus described in the above identified patent is limited to small sections of steel as explained in the recently issued patents to Elmdorf et al. 2,258,566 and Mayo et al. 2,289,138, whereas it is an object of this invention to thermally harden steels to a greater depth by modifying the process and apparatus in the manner explained hereinafter.

While it has been common practice to agitate the quench liquid so as to maintain uniform temperatures throughout the liquid and so as to prevent overheating of the liquid by the heated steel at the point where the steel enters the quench liquid, the rate of agitation formerly provided was not enough to materially effect the depth to which the steel was converted into bainite. It is an object of this invention therefore to improve upon the quench treatment so as to cool the metal to be quenched to a greater depth within the required time. In order to do this the heated quench liquid is agitated very violently the first few seconds after the hot metal has been dumped into the quench liquid.

A further object of this invention is to safeguard against improper operation of the apparatus.

A further object of this invention is to provide an improved means for producing violent movement of a large quantity of quenching liquid.

A still further object is to improve upon the direction of flow of the quenching liquid relative to the direction of movement of the articles discharged from the furnace into the quenching liquid.

Another object is to prevent the heated articles from contacting the air while moving from the furnace into the quenching liquid.

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A further object is to provide means for preventing the small sized particles being treated from being carried away by the liquid.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings, wherein a preferred form of the present invention is clearly shown.

In the drawings:

Fig. 1 is an elevational view, somewhat diagrammatic showing an apparatus embodying my invention;

Fig. 2 is a plan view, with parts broken away, of the apparatus shown in Fig. 1;

Fig. 3 is a sectional view taken on line 3-3 of Fig. 2;

Fig. 4 is a horizontal sectional view taken on line 4-4 of Fig. 3;

Fig. 5 is a fragmentary elevational view showing the apparatus for controlling the dumping of articles from the furnace into the quench bath;

Fig. 6 is a vertical sectional view somewhat diagrammatic showing the liquid agitating means and the path of movement of the quench liquid;

Fig. 7 is a view similar to Fig. 6 showing a modified form of liquid agitating means;

Fig. 8 is a fragmentary sectional view on an enlarged scale taken on line 3-3 of Fig. 2 showing the chute latching mechanism; and

Fig. 9 shows the S curve for a typical steel.

By heating a piece of steel to a temperature of approximately 1500° F. in a hydrizing atmosphere the grain structure of the steel will be transformed into austenite and by transferring the steel thus heated to a quench bath maintained somewhere between 300° F. and 1000° F. the grain structure of the steel will be transformed into bainite which comprises grains other than coarse pearlite or martensite. The temperature at which the quench liquid should be maintained depends upon the type of steel treated and the hardness desired. For most purposes temperatures between 500° F. and 620° F. are preferable.

The general process of heat treating steel to transform austenite to bainite is well known. Likewise, the thermal hardening time curves, commonly known as S curves, are known for many typical commercial steels. A typical S curve is shown in Fig. 9 wherein the line A has been added to illustrate a typical rate of temperature change which will produce bainite and the line B has been added to designate a rate of change which is too slow to pass the nose temperature of the S curve and therefore too slow to

prevent the transformation into pearlite which precludes the transformation into bainite.

No special difficulty is experienced in quenching the outer surface of the articles in the required time but great difficulty has been experienced in cooling the inner portion of the articles within the required time. Prior to my discovery it was considered that the maximum diameter of a round piece of S. A. E. 1095 steel, for example, which could commercially be transformed into bainite by the Bain et al. method was approximately  $\frac{1}{8}$  inch whereas I have found that by using a sufficient amount of quenching liquid and by violently agitating the quenching liquid, the maximum sections of this same type of steel which may be transformed into bainite is several times greater than was formerly considered possible.

The quenching liquid used may be any one of several different liquids. I have found a solution of 55%  $\text{NaNO}_3$  plus 45%  $\text{KNO}_3$  is very effective and does not attack the metal being treated.

Referring now to the drawings wherein I have shown apparatus for thermally hardening metals in accordance with my invention, reference numeral 10 designates a conventional hydrizing furnace having a door 12 through which the articles to be treated may be inserted into the furnace for heating. While the furnace 10 is preferably suspended from the ceiling, any other means for mounting the furnace could be used. Reference numeral 14 designates an insulated tank having an internal diameter of 4 feet and containing quenching liquid to a depth of 26 inches. A chute 16 is provided for directing the articles to be hardened from the furnace 10 to the tank 14.

Within the tank 14 I have provided a revolving rack 18 having six basket-carrying sections 20 which are supported from the main shaft 22 by means of the arms 24 and 25. The main shaft 22 is a hollow shaft which is rotationally journaled in the top wall 26 of the tank 14. The shaft 22 carries a sprocket 30 at its upper end which is connected to the hand operated sprocket 32 by means of a chain or the like 34. The sprocket 32 is carried by the shaft 36 which is provided with a hand crank 38. The cover 26 includes a hinged portion 26a which may be lifted so as to remove and replace the baskets containing the heat treated articles.

The liquid within the tank 14 may be heated by means of a plurality of electrical heaters such as the strip heaters 40 which are uniformly spaced around the periphery of the tank as shown. A thermostat 42 projects into the tank through the cover 26 and serves to control the temperature of the quench liquid in accordance with well-known practice.

A reciprocating shaft 44 passes through the hollow of the shaft 22. A substantially cone shaped agitator 46 having a 21 inch diameter at the base is secured to the shaft 44 as shown so as to reciprocate along with the shaft 44. A walking beam 48 pivoted at 50 on the frame 52 has its one end 54 pivotally connected to the shaft 44 and has its other end 56 pivotally connected to the connecting rod 58 whereby reciprocation of the connecting rod 58 causes a corresponding reciprocation of the shaft 44. The lower end of the connecting rod 58 is operated by means of an eccentric 60 driven by a motor 62 through a reduction gear mechanism 64.

The motor 62 is preferably a two-speed motor designed to cause the agitator 46 to operate at

300 or more strokes per minute at its high speed and to operate at anywhere from 150 to 250 strokes per minute at low speed. I have found that by operating the agitator 46 at 300 strokes per minute with a two inch stroke and a three-quarter inch clearance between the agitator 46 and the bottom of the tub 14, the liquid flows very rapidly in the direction indicated by the arrows in Fig. 6. Since the agitator is required to handle such a large volume of liquid at such a high velocity, a  $7\frac{1}{2}$  horsepower motor is used to operate the agitator. In view of the large amount of power required to produce the necessary velocity of the liquid, the agitator is operated at its high speed for only a short time prior to the dumping of the heated metal and for only a short time after each batch of metal has been dumped. Tests indicate that if the agitator is operated at a high speed for approximately one minute and at a slow speed thereafter for approximately an hour before the metal is removed from the liquid, the desired quenching takes place.

Since the velocity of the quench liquid differs in different locations along the path of the falling metal and since the velocity at any one point fluctuates due to the pulsations produced by the reciprocating agitator, it is difficult to state the exact velocity in terms of feet per minute above which the liquid must flow in order to materially increase the depth to which transformation to bainite takes place. It is a simple matter, however, to determine when the velocity is high enough by heat treating sample pieces of a given type of steel such as S. A. E. 1095 steel and then checking the maximum section which is transformed into bainite. Without adequate agitation of the liquid the maximum section of S. A. E. 1095 steel which may be transformed is approximately one eighth of an inch whereas with agitation as provided by my apparatus the maximum section which may be transformed is several times greater.

In Fig. 7 I have shown a modified agitator construction which is designed to concentrate the flow of quenching liquid in the one direction. Thus by providing a tilted agitator such as the agitator 46a the velocity of the liquid at the point 68 is much greater than the velocity of the liquid at 69. This being the case the velocity of the liquid at point 70 is much greater than the velocity at 72. By virtue of this construction it is possible to obtain the equivalent of a jet of liquid directed toward the incoming metal to be quenched. However, the volume of liquid in the jet is very great whereby the heat given off by the metal to be quenched is absorbed at a high rate. Referring to Figs. 6 and 7 it will be noticed that the directional flow of the liquid directly beneath the chute 16 is such that it flows at right angles to the direction of movement to the metal dumped from the chute.

Inasmuch as the success of the quenching operation depends considerably upon the velocity of the liquid striking the hot metal to be quenched it is desirable that the basket designated by the reference numeral 74 into which the hot metal is dumped be highly perforated so as not to materially restrict the flow of liquid. The perforations 76 have been diagrammatically represented in Fig. 8. Obviously the entire basket is provided with perforations. For certain purposes baskets made from wire screen may be used. In order to simplify the disclosure somewhat, only one basket has been shown in the rack in Figs. 3 and 4

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whereas the rack would normally have a basket in each of the sections 20.

In order to make sure that the basket carrying rack is properly positioned so that there is a basket directly under the chute to receive the metal articles dumped from the chute, I have provided a first indexing means comprising a lever 78 which is carried by the side wall of tub 14 as shown at 30, Fig. 4 and which engages the notches 82 provided on the basket carrying racks 20.

In addition to the indexing means for properly positioning the basket-carrying rack, I have provided further means for preventing dumping material into the quench bath in the event that no basket has been placed in the basket-carrying section directly beneath the chute. As best shown in Figs. 1 and 3 the chute 16 comprises an upper section 84 which is secured directly to the furnace 10 and a lower portion 86 secured to the lever 88 by means of the pins 90. The lever 88 is fulcrumed on the cover 26 by means of the fulcrum element 92. A latch element 94 is provided with a latch 96 which is arranged to engage a stop 98 on the chute section 86 in the event that a basket has not been placed in the rack section directly beneath the chute. The element 94 is provided with a depending arm 100 which cams the latch 96 out of the path of the stop 98 when a basket moves beneath the chute. As shown in Figs. 4 and 8 each basket is provided with a projecting cam surface 102 which is arranged to engage the arm 100 and move it into the dotted line position when the basket is directly beneath the chute. In order to facilitate removal of the baskets at the completion of the quenching operation each basket is provided with handles 104 as shown in Fig. 3.

An interlock has also been provided between the means for dumping the hot metal from the furnace into the chute and the chute lowering mechanism. Referring to Fig. 5, reference numeral 106 designates a handle which serves to dump the hot metal particles from the furnace into the chute. The handle 106 is provided with a crosspiece 108 to which opposite ends of a cable 110 are secured as shown in Fig. 5. The cable 110 is secured to the lever 88 at its outer end 112 whereby movement of the handle 106 tends to raise or lower the chute section 86. By virtue of this construction it is impossible to dump the heated metal from the furnace into the chute when there is no basket beneath the chute to cam the latch 96 away from the path of the stop 98. In the lower position of the chute element 86 the chute element 86 projects within the basket whereby the quench liquid flowing substantially at right angles to the outlet of the chute cannot prevent the falling articles from falling into the basket.

Since the success of the quenching operation depends upon the high liquid velocity it is important that the motor 62 be operating at its highest speed for a short time before each batch of metal is dumped and for a short time after each batch is dumped. I have provided means for preventing the operation of the dumping lever 106 except at those times when the motor 62 is operating at its high speed. As shown in Fig. 5 I have provided a conventional time switch 116 which is used for timing the motor operation in accordance with well-known practice. By manually pressing the time switch button 118, the motor speed control relay 120 causes the motor

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to be operated at its full speed for the desired length of time. Shortly after depressing the button 118 the relay 122 is energized and this retracts the latch 124 which would otherwise prevent operation of the lever 106. By virtue of this construction it becomes necessary for the operator to first depress the button 118 so as to step up the speed of the motor and then wait a predetermined length of time for the latch 124 to be retracted before dumping the heated metal into the quench bath.

The time switch 116 is set to automatically de-energize the relay 120 after a predetermined length of time depending upon the type of metal being treated, etc. Likewise, the time switch 116 deenergizes the relay 122 after a predetermined length of time which may be set so as to give enough time to return the handle 106 to its full line position as shown in Fig. 5. Electricity is supplied to the time switch 116 through the lines 130 whereas electricity is supplied to the motor 62 through the lines 132. Inasmuch as time switches of this type are well-known and inasmuch as the specific construction of the time switch does not enter into this invention no further description thereof needs be given.

The temperature values, time values, etc., given herein have been given for purposes of illustration as it is apparent that these values may be varied somewhat without departing from the spirit of my invention.

While the form of embodiment of the invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, as may come within the scope of the claims which follow.

What is claimed is as follows:

1. Apparatus for thermally hardening steel comprising in combination, a furnace for heating said steel to a temperature at which the steel is converted substantially fully to austenite, a receptacle adapted to contain a quench liquid, means for maintaining said liquid at a temperature below 1000° F. but above the temperature at which rapid formation of martensite is produced, means for agitating said liquid, means for dumping the steel from said furnace into said quench liquid, said means for agitating said liquid comprising a variable speed agitator, and interlocked means between said speed varying means and the means for conveying the steel from said furnace into said quench liquid comprising means for preventing heated steel from being dumped into said liquid when said agitator is operated at a slow speed.

2. Apparatus for thermally hardening steel comprising in combination, a furnace, a quench liquid receptacle disposed substantially beneath said furnace, a chute for conveying heated articles from said furnace to said receptacle, basket holding means within said receptacle adapted to removably support a basket beneath said chute, means for dumping heated articles from said furnace through said chute into said basket, means for preventing operation of said dumping means in the absence of a basket beneath said chute, means for agitating the quench liquid within the receptacle, variable speed means for operating said agitating means, and interlock means between said variable speed means and said dumping means comprising means for preventing operation of said dumping means when said agitator is operated at slow speed.

3. Apparatus for thermally hardening steel

comprising in combination, a furnace for heating said steel to a temperature at which the steel is converted substantially fully to austenite, a receptacle adapted to contain a quench liquid, means for maintaining said liquid at a temperature below 1000° F. but above the temperature at which rapid formation of martensite is produced, means for agitating said liquid, means for dumping the steel from said furnace into said quench liquid, and interlocked means between said agitating means and the means for conveying the steel from said furnace into said quench liquid comprising means for preventing heated steel from being dumped into said liquid when said agitator is ineffective to properly quench said steel.

4. Apparatus for thermally hardening steel comprising in combination, a furnace, a quench liquid receptacle disposed substantially beneath said furnace, a chute for conveying heated articles from said furnace to said receptacle, basket holding means within said receptacle adapted to removably support a basket beneath said chute, means for dumping heated articles from said furnace through said chute into said basket, means for preventing operation of said dumping means in the absence of a basket beneath said chute, means for agitating the quench liquid within the receptacle, and interlock means between said agitating means and said dumping means comprising means for preventing operation of said dumping means when said agitator is ineffective.

5. Apparatus for thermally hardening metal comprising in combination, a furnace for heating said metal, a receptacle adapted to contain a quench liquid, means for agitating said liquid, means for dumping the metal from said furnace into said quench liquid, and interlock means between said agitating means and the means for conveying the metal from said furnace into said quench liquid comprising means for preventing heated metal from being dumped into said liquid when said agitator is ineffective to properly quench said metal.

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