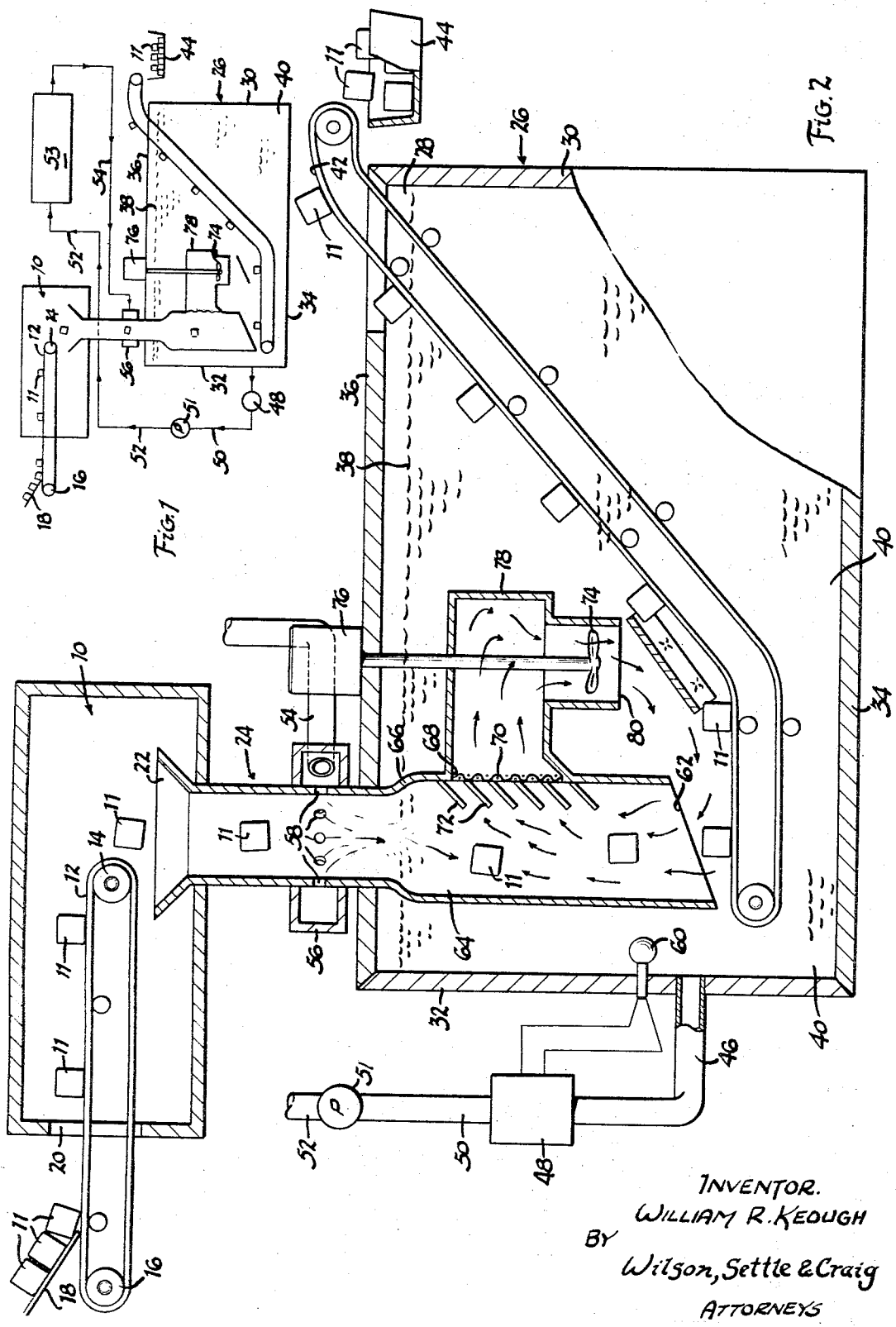
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HEAT TREATING QUENCHING METHOD AND APPARATUS

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HEAT TREATING QUENCHING METHOD AND APPARATUS

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ABSTRACT OF THE DISCLOSURE

A device for heat treating articles discharged from a heating furnace. The device includes a reservoir having a vertical chamber with inlet and outlet openings through which the article descends. A fluid egress port is provided intermediate the openings and communicates with fluid circulating means which is adapted to circulate the cooling fluid between the lower outlet opening and the egress port to provide a vertical fluid flow component acting against the gravational forces on the workpiece thereby extending the period of time the workpiece is maintained in the cooling fluid. Also, cascading streams of fluid intersecting at a common point intermediate the side walls of the chamber and above the surface of the cooling fluid prevent upward splashing of cooling fluid as the article enters the cooling fluid.

This invention relates to the heat treating of articles, and more particularly to improvements in methods and apparatus for quenching heated metal articles from a heat treating furnace into a quenching bath.

The present invention is especially concerned with the type of heat treatment process wherein metal articles are conveyed through a heat treatment furnace at a rate chosen to achieve the desired exposure of the article to heat during its transit through the furnace and to discharge the article from the conveyor directly into a quenching bath.

This type of treatment process has, in the past, presented two principal problems. First, the rate of cooling, merely by immersion of the heated metal articles in the relatively cooler quenching medium, is often insufficient to harden the articles to the degree desired. Second, the initial contact between the articles being discharged from the heat treatment furnace and the surface of the quenching bath frequently occasioned splashing or splash-back of the quenching medium into the furnace, thereby accelerating corrosion and deterioration of the furnace components resulting in costly, more frequent repairs and replacement of components.

The apparatus disclosed by this application utilizes novel techniques and structure to materially speed up the rate of cooling of the heated metal articles per unit of time during quenching, while alleviating splash-back into the heat treatment furnace.

Accordingly, it is a primary object of the present invention to circulate the quenching fluid in a novel pattern through a quenching zone beneath the surface of a quenching bath by novel apparatus to turbulently impinge quenching fluid with a predetermined velocity against each article during its movement through the quenching zone to increase the measure of metal hardness attainable by increasing the quantity of quenching fluid which contacts the surface of each article per unit of time and by increasing the turbulence induced by impact between the circulated fluid and the moving article.

It is another important object of this invention to provide a heat treatment installation wherein articles are quenched to a higher state of hardness in a quenching bath which is circulated countercurrent to the descent

of the articles through a quenching zone in the bath following being dropped directly from a heat treatment furnace into a quenching bath in a manner such that upward splashing normally created by entry of the article into the quenching bath is minimized by a quenching stream smothering phenomenon.

The foregoing and other objects are achieved in an installation in which normally a conveyor is employed to convey articles through a heat treatment furnace and to discharge the heated articles into a quenching bath located below the discharge end of the conveyor. The quenching bath is contained in a tank divided into compartments. A vertical passage or tube is open at both ends and projects downwardly into the quenching bath and upwardly above the quenching bath. Articles discharged from the furnace conveyor drop downwardly through an article inlet opening in this passage into a quenching zone of the bath, pass through the quenching zone, and are discharged through an article outlet opening in the passage, preferably located near the bottom of the quenching tank. Apparatus such as an endless conveyor belt may be used to remove the quenched articles from the tank, following their discharge from the article outlet opening of the vertical passage.

At a location above the normal level of the quenching fluid in the tank, quenching fluid discharge structure is provided for discharging recirculated quenching fluid into the vertical conduit of the tank using a plurality of radial, gravity-fall, orifice-discharge trajectory stream components, preferably having essentially a common point of intersection. The heated metal articles are preferably discharged from the furnace into the general vicinity of the trajectory intersection. Inasmuch as the trajectory stream components of quenching fluid each have a substantial downward component at their point of common intersection, introduction of falling heated articles into the continuously flowing fluid trajectories tends to suppress upward splashing of the quenching fluid caused by entry of the articles into the bath to thereby avert back splash of the fluid into the furnace with its attending problems.

A fluid circulation pump is housed in a chamber at a location beneath the normal level of the quenching fluid in the tank at a location adjacent an aperture in one side of the vertical passage. To achieve a high rate of cooling to thereby produce metal articles having a greater state of hardness, a high velocity, highly turbulent flow of fluid is pump-circulated through the article discharge end of the vertical passage to impinge against and, if desired, to partially suspend the descending articles being quenched. Baffle plates internal of the vertical passage cause the circulation fluid to discharge through the side aperture in the passage and to thereafter pass through the pump chamber. The velocity rate of the fluid circulation flow in the vertical passage is preferably such as to resist gravity descent of the articles through the fluid, allowing for gradual downward movement of the articles, without forcing the articles into the immediate vicinity of the side aperture, which is preferably covered by screens to protect the pump impeller.

Other objects and features of this invention will become more fully apparent from the appended claims as the ensuing detailed description proceeds in conjunction with the accompanying drawings in which:

FIGURE 1 is a side elevational schematic view, partly in section, of heat treatment apparatus including a furnace and a quenching bath tank; and

FIGURE 2 is an enlarged side elevational view, partly in section, illustrating in detail the quenching bath tank of FIGURE 1.

Referring now in detail to the figures, in FIGURE 1 there is shown a heat treatment furnace **10** more or less of conventional construction which takes the form of a

thermally insulated tunnel through which metal parts or articles **11** to be heated are conveyed on the upper run of an endless conveyor belt **12**. Conveyor belt **12** is trained around an idler **14** and a drive roller **16**. Drive roller **16** may be driven by conventional conveyor drive apparatus (not shown) and in a direction such that the upper run of belt **12** moves from left to right, as viewed in FIGURE 1.

Articles **11**, to be conveyed through the furnace, are fed onto the upper run of belt **12** from an infeed chute **18**. Suitable infeed conveyor apparatus (not shown) may also be provided for depositing articles **11** upon chute **18**.

As articles **11** are conveyed by belt **12** through furnace opening **20** and thereafter through furnace **12**, they are exposed to the high temperature maintained in the interior of the furnace by suitable number of burners (not shown). The temperature within the furnace **10** and the speed of movement of the upper run of conveyor belt **12** through the furnace is normally cooperatively adjustable to achieve the desired heat exposure of the articles during their transit through the furnace.

When the parts reach the discharge end of the conveyor adjacent idler **14**, they drop freely from the belt downwardly through a furnace opening **22** in the bottom of furnace **10** and into the article inlet end of a hollow chamber or passage **24** which extends downwardly from opening **22** into quenching reservoir **26**. Reservoir or tank **26** is constructed with outer side walls **28**, end walls **30** and **32**, bottom wall **34** and top wall **36**. Tank **26** is normally not pressurized above fluid surface **38** of the body of quenching fluid bath **40**. A belt conveyor **42** is suitably mounted for withdrawal of quenched parts from quenching body **40** as the articles descend from the passage **24** onto the upper run of conveyor **42**. Conveyor **42**, as illustrated, may take the form of an endless belt driven by suitable means (not shown), so that its upper run is driven from left to right, as viewed in the figures, to carry the quenched articles which drop through hollow passage **24** onto the belt from the bath of quenching fluid contained within tank **26** to discharge the parts or articles into a suitable receiving apparatus, schematically indicated as **44** in FIGURES 1 and 2.

With particular reference to FIGURE 1, the quenching fluid contained within tank **26**, preferably oil or water, is recirculated through conduit **46**, electric valve **48**, conduit **50**, pump **51**, conduit **52**, heat exchanger **53**, conduit **54**, annular chamber **56** and a plurality of orifices **58**, where it is discharged in the form of downwardly directed trajectories at a location above the surface of the reservoir. As illustrated in FIGURE 2, electric valve **48** may be thermostatically controlled by thermostatic bulb **60**, so that when the quenching fluid contained within the reservoir reaches a predetermined high or a predetermined low temperature, as the case may be, electric valve **48** opens to supply quenching fluid to heat exchanger **53** which normally cools the fluid to within a desired temperature range, although it may function to heat the fluid to within a desired temperature range, depending primarily upon the nature of the quenching medium.

Preferably, however, the quenching liquid contained within tank **26** is continuously recirculated by pump **51** during quenching operation to avoid splash-back of quenching fluid into the furnace.

Fluid flow emanating from heat exchanger **53** may be adjustably controlled such that liquid is discharged from annular chamber **56** through radial orifices **58** to generate gravity induced downwardly extending flow trajectories which intersect each other centrally of hollow passage **24** at a level substantially below the orifice level and above the reservoir level. In this manner, the common intersection of the orifice trajectories within hollow passage **24** produce a downwardly directed stream.

Because of the extremely high temperatures maintained in furnace **10**, special material is required frequently for fabrication of the furnace components such as conveyor belt **12**. Such special components are normally extremely expensive and frequently are easily corroded by the quenching fluid from the reservoir when splashed into the furnace by the heated articles entering the quenching bath. Also, the introduction of some quenching fluids into the furnace may induce an explosion making the heat treatment installation a hazard to human life. While it is important to minimize splash-back into the furnace, it is also normally necessary to minimize the amount of space between the discharge end of conveyor **12** and the surface of reservoir **40**, since the quenching efficiency requires minimizing the possible time lapse between article discharge from the furnace and initial quenching to obviate substantial cooling of the article during this stage.

In order to space the discharge end of conveyor belt **12** closely adjacent to the surface of reservoir **40**, while at the same time endeavoring to prevent splashing of the quenching fluid into furnace **10**, the quenching fluid is recirculated in the manner described above to occasion the described downwardly extending orifice flow trajectories. The discharge end of belt **12** is located so that the parts drop from the discharge end of the belt downwardly generally through the common point of interesction of the trajectories near the center of flow passage **24** where a stream is formed having a substantial downward component of flow. The normal level of liquid in hollow passage **24** is such that the surface of the liquid bath is located below the common intersection of the trajectories, thus the splash created as the article drops into the main body of quenching liquid is smothered by the continuously flowing, downwardly directed stream.

Hollow passage **24**, intermediate the common intersection of the orifice-flow trajectories and the article outlet opening **62**, forms a quenching zone or region **64** through which the articles descend by force of gravity. The temperature of the quenching fluid in the reservoir is lower than the temperature of the heated articles discharged from furnace **10**. Thus, the articles are rapidly cooled when immersed in the quenching fluid, which rapidly absorbs heat from the articles being quenched. It has been determined that the degree of hardness attainable by merely immersing a heated article in quenching fluid is limited. It has further been determined that the degree of hardness attained is directly correlative with the cooling rate attained during quenching, i.e., the rate at which the heat is absorbed by the quenching fluid. Experimentation has indicated that the cooling rate during quenching may be accelerated by force impinging quenching fluid against the surface of articles being quenched. Apparently, acceleration of the quenching cooling rate is a function of both the velocity at which the quenching fluid impinges against the surface of the article and the quantity of quenching fluid so impinged, due to the inherent turbulent effect created by contact between the relatively hotter articles with the relatively cooler quenching fluid.

The structure embodied within the quenching zone of hollow passage **24** and immediately adjacent thereto uniquely generates a circulation of quenching fluid beneath the surface of the reservoir countercurrent to the descent of the article through the quenching zone which materially accelerates the quenching cooling time through rapid impingement of the counter-current flow onto the surface of the articles being quenched. This results in production of quenched articles having an increased state of hardness.

Structurally, by inspection of FIGURE 2, hollow passage **24** is preferably a circular conduit **66**, although not necessarily so. As stated earlier, heated articles are discharged from furnace **10** into furnace opening **22** of hollow passage **24** and are discharged through article outlet opening **62** upon the upper run of conveyor **42** which subsequently discharges the articles into receptacle **44**. Conduit **66** of hollow passage **24** is, by inspection, partially submerged in the quenching fluid reservoir **40**.

Fluid egress side port **68** is situated beneath bath sur-

face 38 of the reservoir in one side of the conduit 66. Port 68 is preferably covered by screen 70 adjacent to inwardly extending, downwardly directed baffle plates 72. Adjacent side port 68 is impeller 74 of pump 76 housed in flow chamber 78. Pump 76 is preferably a variable speed pump and is continuously operated to circulate quenching fluid beneath the surface of the reservoir by expelling the fluid from chamber 78 through opening 80, some of the discharge impinging upon baffle 82 which prohibits displacement of quenched articles 11 being conveyed upon the upper run of conveyor belt 42. The fluid discharged through opening 80 is circulated through conduit 66 between discharge opening 62 and screened side port 68 to thereby provide a countercurrent flow which impinges upon descending articles 11, which are being quenched. Thereafter, the subsurface circulating flow is deflected against downwardly extending baffles 72, through screen 70 and along chamber 78 toward opening 80, as indicated by the arrows of FIGURE 2.

The elevated stream of quenching fluid emanating tthrough orifices 58 and which passes downwardly within conduit 66 is also diverted through side port 68.

Preferably, the countercurrent flow within the quenching zone of conduit 66 has a substantial upward vertical component and impinges against the articles being quenched with an appreciable velocity such as to restrain the articles against free gravity descent. The degree of restraint may be adjusted by controlling the speed at which pump 76 is operated, depending upon the material being quenched and the degree of hardness which is desired. For example, to calibrate the pump 76 for a minimum rate of article descent, articles are placed within the quenching zone and the pump speed is increased until the articles are displaced against the screen 70 and baffle plates 72, following which the pump speed is decreased until the articles exhibit a visibly evident slow gravity descent. It is possible to cycle the pump 76 to floatingly suspend each article being quenched essentially against any descent for the period of quenching time desired.

To prevent clogging of side port 68, it is necessary to control the speed at which pump 76 is operated, so that the articles being quenched are not displaced into the immediate vicinity of the baffle plates 72 nor adjacent the internal face of screen 70. Therefore, within the limits of free gravity descent of the articles and displacement of the articles into the immediate vicinity of screen 70, the articles may be subjected to high velocity impingement by the countercurrent circulating flow within quenching zone 64 to thereby accelerate the quenching cooling rate of the articles to increase the hardness of the quenched articles.

The invention may be embodied in other specific forms without departure from the spirit or essential characteristics thereof. The present embodiment is therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore to be embraced therein.

What is claimed and desired to be secured by United States Letters Patent is:

1. In a heat treatment apparatus for heating and quenching metal articles, a reservoir disposed at the discharge end of a heat treatment furnace containing a body of quenching fluid in which the articles are quenched, an enclosed hollow chamber essentially vertically interposed between the furnace discharge and the reservoir, being at least partially submerged in the quenching fluid to define a quenching zone through which the articles descend said hollow chamber having article charging and discharging openings and at least one fluid egress port, fluid displacement means including a pump and fluid conveying means including passages to continuously cascade a stream of quenching fluid into the hollow chamber near the charging opening from a point above the surface of the reservoir by creating a common intersection having a substantial downward vertical flow component from a plurality of stream components defined by essentially opposed, gravity induced, orifice-flow trajectories, means for discharging the heated articles from the furnace into the common intersection of the stream components to thereby minimize upward splashing occasioned by entry of the articles into the reservoir, and fluid circulating means including a pump and flow passages disposed external of the hollow chamber adjacent and in fluid communication with the fluid egress port and the discharge opening operable to create a circulating pattern of fluid flow beneath the surface of the reservoir which is directed with a substantial upward vertical flow component through the hollow chamber between the discharge opening and the fluid egress port to impinge upon the surface of the articles being quenched.

2. In a heat treatment process wherein articles to be treated are discharged from a heat treatment furnace into a quenching bath following heating, comprising the steps of: continuously cascading a stream of quenching fluid into a generally enclosed quenching zone within said bath from a point above the surface of the bath by creating a common intersection of a plurality of essentially radial, gravity induced, orifice-flow trajectories, dropping heated articles to be quenched from the furnace downwardly into said quenching zone through said common intersection where said stream has a substantial downward component to thereby minimize any upward splashing effect created by entry of the article into the bath, vertically descending the article through the quenching zone, circulating a continuous flow of quenching fluid beneath the surface of the bath through an article-exit opening in the enclosed quenching zone, imparting a substantial upward flow component to the continuous flow counter to the descending movement of the article through the enclosed quenching zone, impinging the continuous counterflow upon the surface of the article to quicken the quenching cooling rate and thereby produce an article of increased hardness and restraining the article against normal gravity descent to slow its rate of displacement through the quenching zone while maintaining the article within the zone away from the periphery thereof, and laterally deflecting the continuous flow of quenching fluid to discharge the fluid from the quenching zone through a side port.

3. In a heat treatment apparatus for heating and quenching metal articles, a reservoir disposed at the discharge end of a heat treatment furnace containing a body of quenching fluid to quench the articles, an enclosed regional hollow passage interposed between the furnace discharge and the reservoir, said passage being partly submerged in the quenching fluid to define a quenching zone through which the articles pass, and having article charging and discharging openings and a side port with internally extending flow deflecting baffles adjacent the side port, and chamber enclosed fluid circulating means disposed external of the passage adjacent and in fluid communication with the discharge opening and side port to create a circulating pattern of flow beneath the surface of the reservoir which traverses through the passage between the discharge opening and the side port to impinge upon and to partially retard the rate of movement of the articles being quenched as they are moved through the quenching zone without displacing the articles against the screened side port.

4. In a heat treatment process wherein articles to be treated are discharged from a heat treatment furnace into a quenching bath following heating, the steps of dropping an article from the furnace into a predetermined region having ingress and egress ports for gravitational, substantially vertical movement through the region, and providing a substantially upward vertical flow of bath fluid through the egress port in a generally upward direction countercurrent to the direction of movement of said article

to (1) impinge the countercurrent flow of fluid upon the article, thereby quickening the rate of cooling of said article and (2) inhibit the gravitational movement of the article thereby increasing the residence time of the article in said fluid to produce an article of increased hardness.

5. In a heat treatment apparatus for heating and quenching metal articles, a reservoir disposed at the discharge end of a heat treatment furnace containing a body of quenching fluid in which the articles are quenched, an enclosed hollow chamber essentially vertically interposed between the furnace discharge and the reservoir, being at least partially submerged in the quenching fluid to define a quenching zone through which the articles descend, said hollow chamber having article charging and discharging openings and at least one fluid egress port, and fluid circulating means including a pump and flow passage means disposed external of the hollow chamber adjacent and in fluid communication with the fluid egress port operable to create a circulating pattern of fluid flow beneath the surface of the reservoir which is directed with a substantial upward vertical flow component through the hollow chamber between the discharge opening and the fluid egress port to impinge upon the surface of the article being quenched to accelerate the rate of cooling and adjustable to partially retard the rate of descent of the article through the quenching zone to thereby produce finished articles of increased hardness.

6. A heat treatment process comprising the steps of: heating articles to be treated in a heat treatment furnace, discharging the articles, according to a predetermined pattern, from the furnace into an article receiving opening of an enclosed region of a quenching bath, moving each of said articles along a decreed course through the enclosed region, circulating a continuous flow of quenching fluid through an article discharge end of the enclosed region, imparting a substantial velocity component to the continuous flow in said enclosed region counter to the decreed course of movement of the articles through the quenching region, impinging the continuous counterflow upon the surface of the article to create turbulent contact therebetween and restraining the rate of article-movement without materially altering the direction of article-movement through the quenching region to quicken the quenching rate, laterally deflecting the continuous flow of quenching fluid to discharge the flow from the enclosed region, removing the articles from the quenching region, and discharging the articles from the quenching bath.

7. In a heat treatment apparatus for heating and quenching metal articles, a reservoir disposed at the discharge end of a heat treatment furnace containing a body of quenching fluid in which heated articles are quenched, an enclosed, partially submerged quenching region within the reservoir disposed adjacent the furnace discharge, said region having spaced article-inlet and article-outlet openings and fluid egress means and fluid circulating means disposed external of the quenching region adjacent and in fluid communication with the fluid egress means to create a circulating pattern of flow beneath the surface of the reservoir which traverses through the quenching zone between the article-outlet opening and the fluid egress means to impinge upon the articles being quenched as they are moved through the quenching zone.

8. In a heat treatment apparatus for heating and quenching metal articles, a reservoir disposed at the discharge end of a heat treatment furnace containing a body of quenching fluid in which the articles are quenched, an enclosed hollow chamber essentially vertically interposed between the furnace discharge and the reservoir, being at least partially submerged in the quenching fluid to define at least part of a quenching zone through which the articles descend, said hollow chamber having article charging and discharging openings and at least one fluid egress port, fluid displacement means and fluid conveying means to continuously deposit a stream of quenching fluid into the hollow chamber near the charging opening thereof from a point above the surface of the reservoir, means for discharging the heated articles from the furnace into said stream to thereby minimize upward splashing occasioned by entry of the articles into the reservoir, and fluid circulating means disposed external of the hollow chamber adjacent and in fluid communication with the fluid egress port operable to create a circulating pattern of fluid flow beneath the surface of the reservoir which is directed with a substantial upward vertical flow component through the hollow chamber between the discharge opening and the fluid egress port to impinge upon the surface of the articles being quenched to accelerate the rate of cooling and adjustable to partially retard the rate of descent of the articles through the quenching zone without laterally displacing the articles into the immediate vicinity of the fluid egress port to thereby produce quenched articles of increased hardness.

9. In a heat treatment process wherein articles to be treated are discharged from a heat treatment furnace into a quenching zone of a bath following heating, the steps of gravity descending the article through the quenching zone following discharge from the furnace, continuously circulating quenching fluid through an article exit opening into said quenching zone, imparting a flow direction to the circulating fluid counter to the article descent to (1) impinge the continuous counterflow upon the surface of the article, (2) restrain the rate of movement of the article through the enclosed quenching zone and (3) avoid materially changing the direction of movement of the article through the quenching zone to thereby quicken the rate of cooling per unit of quenching time, and laterally deflecting the circulating fluid for discharge from the quenching region through a side port.

10. A heat treatment process as defined in claim 4, further including the step of deflecting the upward vertical flow of bath fluid from the predetermined region at a point intermediate the ingress and egress ports.

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