# United States Patent

**Schrader et al.**

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[45] **Aug. 29, 1972**


[54] **QUENCH SYSTEM**


[72] Inventors: **Carlton F. Schrader,** Chesteron; **Harold L. Taylor,** Hammond, both of Ind.; **William E. Heitmann,** Dolton, Ill.

[73] Assignee: **Inland Steel Company,** Chicago, Ill.



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[52] **U.S. Cl.**.....**134/114,** 134/122

[51] **Int. Cl.**.....**C21d 1/00,** B08b 3/02

[58] **Field of Search**.....134/15, 64, 114, 122, 199



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*Primary Examiner*—Robert L. Bleutge

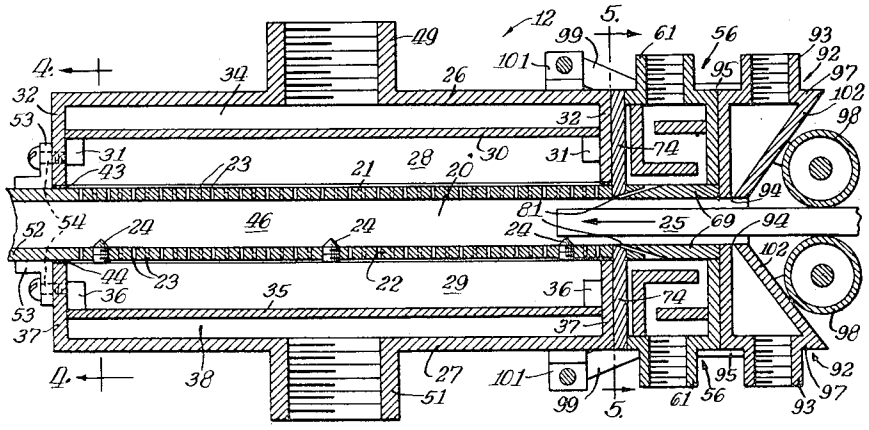
*Attorney*—Hibben, Noyes & Bicknell



[57] **ABSTRACT**

A heated metal work-piece, particularly a metal plate, is quenched by passing it through an elongated restricted quench channel filled with quench liquid flowing at high velocity. Quench liquid is supplied at the channel inlet in the form of submerged liquid sheets directly angularly against opposite sides of the work piece. Sealing liquid is provided upstream from the liquid sheets to prevent air aspiration into the channel. Submerged jets of quench liquid may be introduced into the channel downstream from the liquid sheets. Sealing rolls may be provided adjacent the channel inlet for sealing engagement with the work-piece during entry into the channel.


**8 Claims, 6 Drawing Figures**



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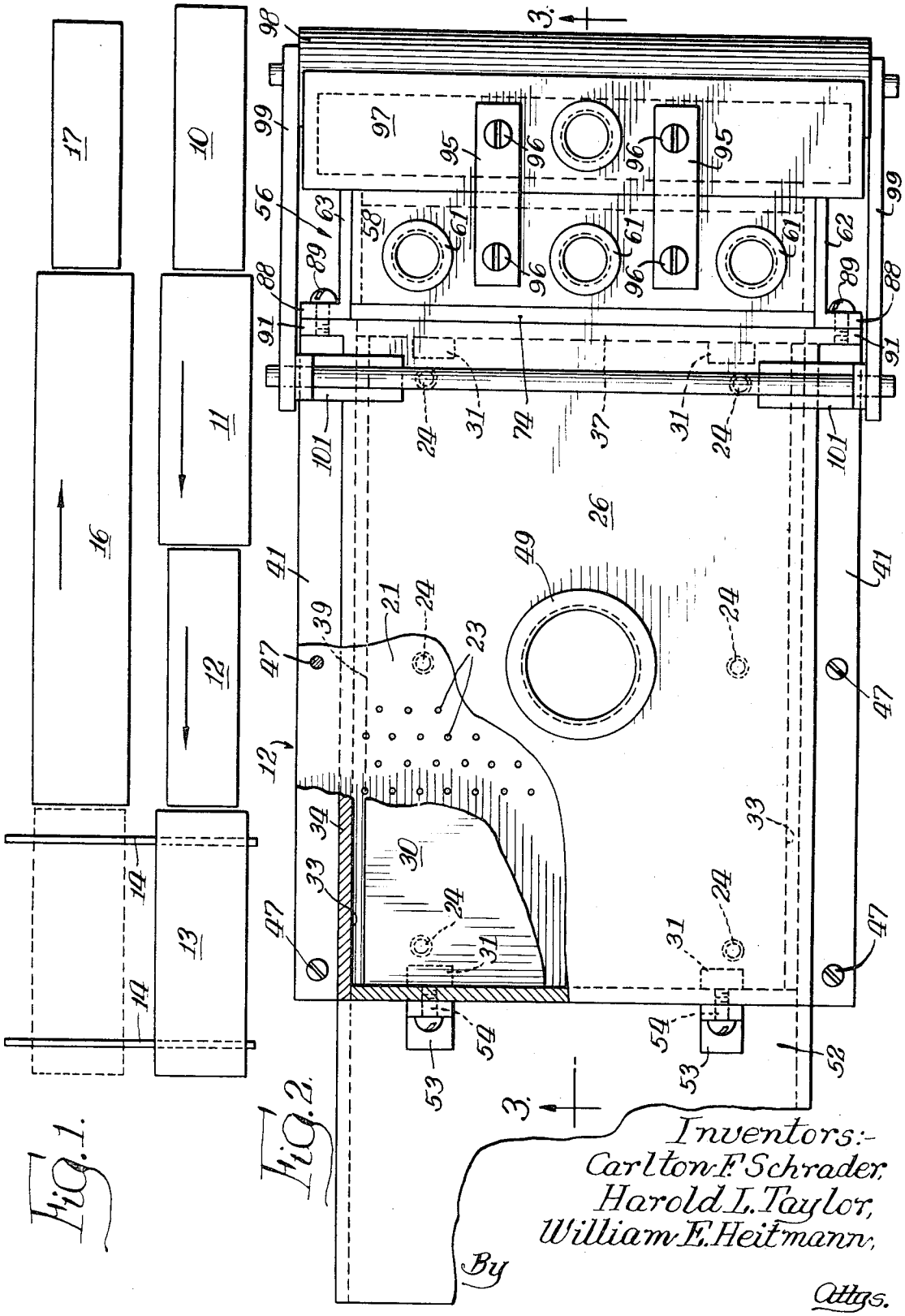


FIG. 1.

FIG. 2.

Inventors:-
Carlton F. Schrader,
Harold L. Taylor,
William E. Heitmann,

By

Attys.

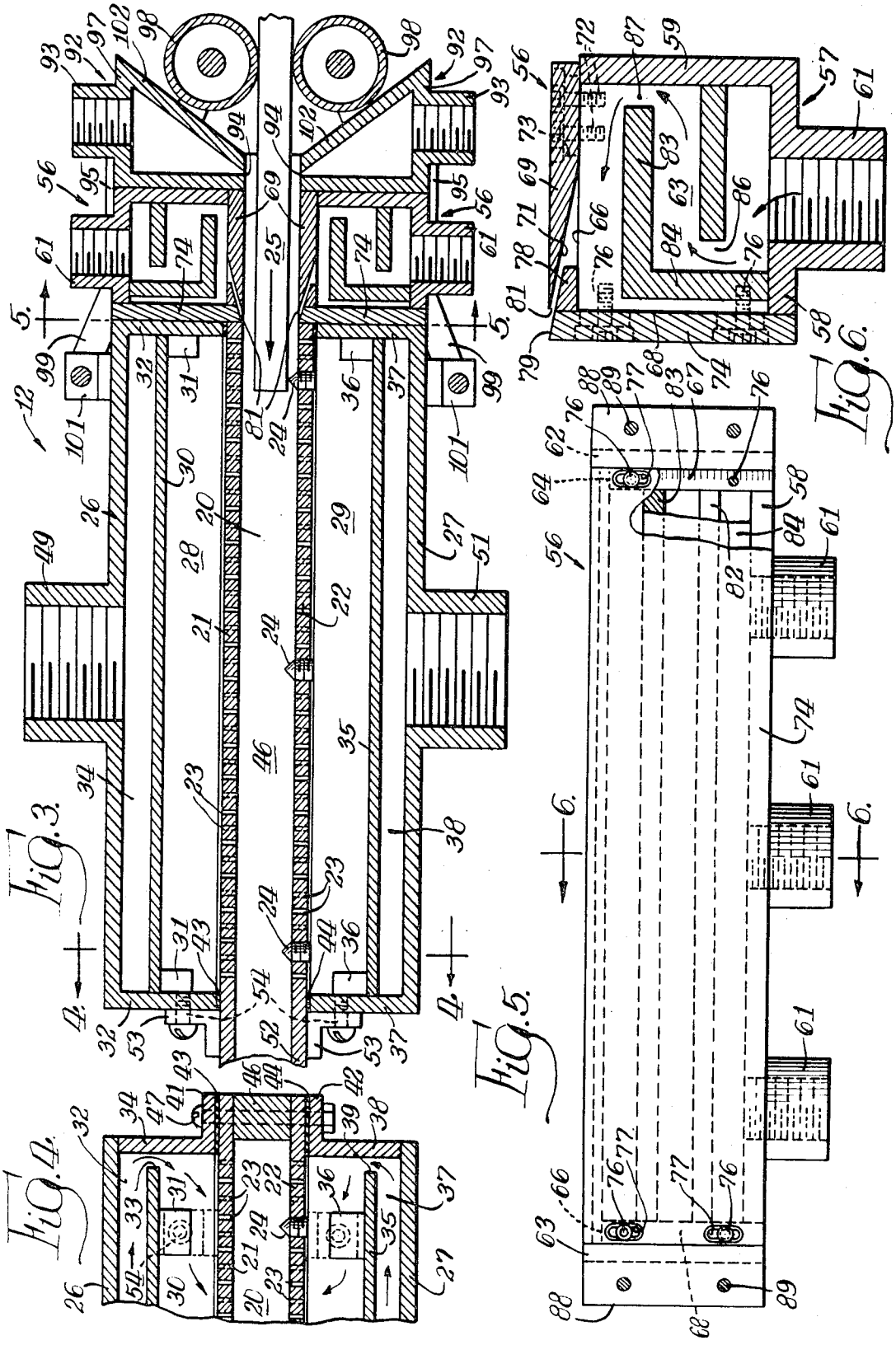


FIG. 3.

FIG. 4.

FIG. 5.

FIG. 6.

# QUENCH SYSTEM

This application is a division of application Ser. No. 585,516, filed Oct. 10, 1966, now U.S. Pat. No. 3,531,334.

This invention relates to a novel apparatus for quenching metal in strip, sheet, or plate form. The invention relates particularly to the quenching of steel plates.

In the industrial processing of metal in sheet, strip, or plate form, rapid quenching is often required. Specifically, in the steel industry rapid quenching is frequently required at the exit and of a hot strip mill or following an austenitizing furnace in a quench and temper heat treating line for steel plates. At the present time, these quenching operations are carried out primarily by means of water sprays.

In a quench system using water sprays great difficulty has been encountered in providing the required severity of quench so as to obtain the desired properties in the quenched product. The problem is particularly acute when quenching plain carbon or low alloy steel plates having a substantial thickness. Furthermore, uniformity of quenching and avoidance of distortion or warpage during quenching are additional critical problems which have confronted the steel industry.

In general, two quench techniques have been used commercially in order to effect severe quenching of heated steel plates by means of water sprays. In one method, the steel plates have held between hydraulically actuated pressure platens during quenching so as to maintain flatness and avoid excessive distortion. More recently, a roller quench method has been employed in which the steel plate is oscillated between upper and lower sets of rollers while being subjected to the water sprays. However, these existing quench systems are not capable of achieving the desired quench severity, especially for plain carbon steels and relatively thick plates. Moreover, the existing quench systems are characterized by highly inefficient use of the quench water. In any case, the quenched plates usually require flattening by means of rolling or leveling in order to obtain an acceptable shape.

Users of steel plates are demanding increased severity of quench so as to meet the requirements for greater strength and hardness. Moreover, it is now recognized that for superior fatigue properties the quenched plate should have a fully martensitic surface and the quench should be severe enough to place the surface of the plate under high compressive stress.

Accordingly, a primary object of the present invention is to provide a novel and improved system for severely quenching metal, particularly steel, in strip, sheet or plate form.

A further object of the invention is to provide a novel and improved quench system which is particularly adapted for severely quenching plates of plain carbon or low alloy steel.

Another object of the invention is to provide a quench system of the foregoing character in which distortion and warpage are minimized by means of improved uniformity of quench.

Still another object of the invention is to provide a quench system for steel plate which provides a fully martensitic surface and superior fatigue properties.

An additional object of the invention is to provide a novel quench apparatus for achieving the aforementioned results.



Other objects and advantages of the invention will become apparent from the subsequent detailed description taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a schematic layout of a quench and temper line for steel plate embodying the quench system of the present invention;

FIG. 2 is a top plan view of a quench apparatus comprising one specific embodiment of the invention, portions of the structure being broken away for clarity;

FIG. 3 is a longitudinal sectional view taken along the line 3—3 of FIG. 2;

FIG. 4 is a fragmentary transverse sectional view taken along the line 4—4 of FIG. 3;

FIG. 5 is an enlarged side elevational view of a portion of the apparatus as seen along the line 5—5 of FIG. 3; and

FIG. 6 is a transverse sectional view taken along the line 6—6 of FIG. 5.

The quench system of the present invention is illustrated in FIG. 1 as embodied in a heat treating, quenching and tempering line for the processing of steel plates. However, it should be understood that the quench method and apparatus of the present invention may also be used in connection with the processing of steel strip or sheet and are also useful in quenching strip, sheets, or plates of other metals.

In general, the quench system shown in the illustrated embodiment of the invention may be used on plates of plain carbon steel or steel containing added hardenability agents, such as boron, nickel, chromium, molybdenum, and vanadium. However, a particular advantage of the present invention is that it affords a high quench severity such that the desired properties can be obtained in plates of substantial thickness even with plain carbon steels. By way of example, the plain carbon steel may have the following composition (wt. percent): carbon 0.05 to 0.30 (preferably 0.15 to 0.20, particularly where superior weldability is desired); manganese 0.20 to 2.00 (preferably 1.10 to 1.35); phosphorus 0.04 max.; sulfur 0.04 max.; and the balance essentially iron with residual elements in the usual amounts. In most instances a killed steel will be used, in which case the analysis will also include silicon 0.10 to 0.35 wt. percent and in some cases aluminum 0.02 to 0.05 wt. percent. When added hardenability agents are used, the analysis is substantially the same except for the inclusion of one or more of the following in the indicated amounts (wt. percent): boron 0.0005 to 0.006 (preferably, 0.001 to 0.002); nickel 0.50 to 2.00; chromium 0.50 to 2.00; molybdenum 0.10 to 0.50; and vanadium 0.02 to 0.25 (preferably, 0.06 to 0.08). The plate thickness may be from about one-quarter inch to about 1 inch and the plates will have longitudinal and transverse dimensions many times greater than the plate thickness, e.g. a plate width of 24 to 160 inches and a plate length of 8 to 50 feet.

Referring to FIG. 1, the steel plates are loaded onto a charge table 10 by conventional means and are then fed one at a time by conventional means through a furnace 11 wherein the plates are heated to a uniform temperature at least above the $A_1$ critical point so that the steel is at least partially austenitized. For maximum surface hardness and superior fatigue properties, it is desirable that the steel plates be heated above the $A_3$ critical point. More specifically, a temperature within

the range of from about 1,525°F. to about 1,850°F. will be used dependent upon the carbon content of the steel. Thus, the steel is fully austenitized during the heating step and, dependent upon the quench severity and the composition of the steel, the quenched product may be fully or predominantly martensitic.

The quench unit, which constitutes the principal subject matter of the present invention, is designated at 12 in FIG. 1 and is located immediately adjacent the furnace 11. In the quench unit 12 the heated plates are quenched to a temperature at least below the martensite finish temperature of the steel. From the quench unit 12 the plates are discharged onto a transfer car 13 which is laterally movable back and forth along rails 14. From the transfer car 13 the quenched plates enter an elongated tempering furnace 16 wherein the plates are reheated to and held at a temperature of from about 400°F. to about 1,250°F. to restore a certain amount of ductility to the quenched plates. From the tempering furnace 16 the plates are ejected onto a discharge or air cooling table 17.

Referring now to FIGS. 2–6, the quench unit 12 will be described in more detail. As previously mentioned, the quench unit 12 is located closely adjacent the exit end of the furnace 11 so as to minimize heat losses from the plate between the furnace and the quench unit. Preferably, the time of plate exposure between the furnace and the quench unit should be less than five seconds.

As seen in FIGS. 2 to 4, the quench unit 12 comprises an elongated central tubular quench channel 20 defined between a pair of upper and lower walls or plate members 21 and 22 and having a rectangular cross-section. The walls 21 and 22 are preferably formed with a multiplicity of small openings or perforations 23 which are distributed uniformly over the areas of the walls. The lower wall 22 is also provided with a plurality of upstanding supports 24 which are in the form of studs adjustably threaded in openings in the wall 22 and having tapered upper ends for engaging the lower surface of a plate 25 being quenched. The tapered upper ends of the supports 24 provide a minimum contact area so as to avoid interference with the quench effect. By threadedly adjusting the supports 24 in the wall 22, the clearance between the plate 25 and the opposite walls 21 and 22 can be regulated. The direction of movement of the plate 25 is from right to left as indicated by the arrow in FIG. 3.

Upper and lower housings or enclosures 26 and 27, respectively extend outwardly from the walls 21 and 22 to define quench liquid supply chambers 28 and 29. An imperforate baffle plate 30 extends across the chamber 28 and is secured to a plurality of pads 31 mounted on the end walls 32 of the enclosure 26. As seen in FIGS. 2 and 4, the width of the baffle plate 30 is less than the internal width of the chamber 28 so as to provide elongated slots or openings 33 between the side edges of the baffle 30 and the side walls 34 of the housing 26. Similarly, a baffle plate 35 extends across the chamber 29 and is secured to pads 36 mounted on the end walls 37 of the enclosure 27, the baffle plate 35 being spaced from the side walls 38 of the enclosure 27 to provide slots 39. As seen in FIG. 4, the enclosure side walls 34 and 38 have outwardly projecting flanges 41 and 42, and the plate members 21 and 22 extend to the outer edges of the flanges with gaskets 43 and 44 interposed therebetween. A pair of spacer strips 46 are disposed between the outer marginal portions of the plate members 21 and 22 to define the sides of the quench channel 20. The entire assembly is held together by means of a plurality of bolts 47. Inlets 49 and 51 for water or other quench liquid are provided in the outermost walls of the housings 26 and 27.

At the discharge end of the quench unit 12, a guide tube or conduit 52 of rectangular cross-section is mounted in alignment with the quench channel 20 by means of brackets 53 and screws 54 extending into the downstream end walls 32 and 37 of the enclosures 26 and 27.

As hereinafter described in more detail, it is necessary that the quench channel 20 run completely full of water or other quench liquid during passage of a plate 25 therethrough. Furthermore, in order to obtain the desired rapid and severe quench of the heated plates and also in order to protect the heating furnace 11, it is necessary to avoid reverse or back flow of quench liquid in the quench channel 20. To accomplish this objective, the main supply of water or other quench liquid is provided by means of a pair of submerged spray units 56 which are mounted immediately adjacent the upstream end walls 32 and 37 of the enclosures 26 and 27 and the volume flow rate of the quench liquid from the spray units 56 is sufficient to maintain the channel 20 filled with quench liquid. The structural details of the spray units 56 are best seen in FIGS. 5 and 6.

Referring to FIGS. 5 and 6 showing one of the spray units 56 per se, each of the spray units 56 comprises an elongated angle member 57 defining an outer elongated wall 58 and an inwardly extending elongated wall 59. The outer wall 58 is provided with a plurality, in this instance three, of inlets 61 for water or other quench liquid. A pair of end closure plates 62 and 63 are rigidly secured, as by welding, to the opposite end edges of the walls 58 and 59 to define a unitary structure with the angle member 57. The end closure plates 62 and 63 are formed with horizontally extending recessed shoulders 64 and 66, respectively, and with vertically extending recessed shoulders 67 and 68, respectively, at the open sides of the angle member 57. An elongated adjustable plate 69 having a tapered surface 71 is adjustably mounted on the end closure members 62 and 63 by means of a plurality of recessed screws 72 extending loosely through elongated slots 73 into threaded bores in the shoulders 64 and 66. Another elongated adjustable plate 74 is adjustably secured to the end members 62 and 63 by means of a plurality of recessed screws 76 extending loosely through elongated slots 77 into threaded bores in the shoulders 67 and 68. The innermost portion of the plate 74 has an inwardly projecting extension 78 which defines, with the inner end edge of the plate 74, a tapered surface 79 parallel to the taper 71 on the plate 69. The spaced surfaces 71 and 79 define an angularly extending or slanted orifice 81 which is rectangular in cross-section and extends across the channel 20 transversely of the direction of movement of the plate 25. As will be understood particularly from FIG. 6, by horizontal adjustment of the plate 69 and by replacement or adjustment of the plate 74, the width of the angularly extending discharge slot or orifice 81 between

the tapered surfaces 71 and 79 may be requisted as desired.

The interior of the enclosure formed by the angle member 57 and the plates 69 and 74 is provided with suitable baffle means which in this instance comprises an elongated rectangular baffle plate 82 secured to the wall 59 and a transversely spaced baffle plate 83 having an angular leg 84 secured to the wall 58. The free longitudinal edge of the baffle plate 82 has a fixed clearance 86 from the support leg 84, and the free longitudinal edge of the baffle plate 83 has a fixed clearance 87 from the wall 59.

The water or other quench liquid in passing from the inlets 61 to the angular discharge slot or orifice 81 follows a tortuous path in which the direction of flow is reversed several times, as indicated by the arrows in FIG. 6, thereby insuring a uniform flow of liquid across the entire length of the orifice 81. Moreover, the restricted spacings at 86 and 87 serve to trap any large particles of foreign material and thereby prevent obstruction of the orifice 81. If desired, the baffle clearances 86 and 87 may be arranged so that they are narrower or more restricted than the widest opening contemplated for the adjustable orifice 81, thereby insuring that no foreign particles will clog the orifice 81.

As best seen in FIGS. 2 and 5, the spray units 56 have end flanges 88 extending from the end members 62 and 63 which are detachably secured by screws 89 to mating end flanges 91 on the upstream end walls 32 and 37 of the enclosures 26 and 27.

The spray units 56 provide the main source of cooling water or other quench liquid to the channel 20 in the form of submerged liquid sheets or curtains directed at an acute angle into the quench channel 20 in the direction of movement of the plate 25 therethrough. As seen in FIG. 3, the opposed plates 69 of the oppositely mounted spray units 56 provide a continuation of the quench channel 20, and the angular orifices 81 open into the channel 20 at a location adjacent to but slightly downstream from the plate inlet end of the channel 20. Thus, the longitudinal components of the angularly directed sheets of quench liquid from the orifices 81 are in the same direction as the travel of the plates 25 through the quench channel 20, and by insuring a sufficiently high velocity of liquid through the quench channel 20, and by insuring a sufficiently high velocity of liquid through the quench channel 20, undesirable back flow of liquid is avoided. The dimensions of the channel 20 are restricted as to provide a high velocity of flow of quench liquid while still allowing adequate clearance for passage of the plates 25. The angle of the liquid sheets discharged from the orifices 81 may vary from about 5° to about 30° from the horizontal, and an angle of about 10° has been found to give effective results. Moreover, to obtain best results a quench liquid flow velocity in the channel 20 relative to the plate 25 of at least about 10 ft./sec. is required. As mentioned above, the volume flow rate of water or other quench liquid supplied by the spray units 56 must be sufficient so that the channel 20 always runs completely full of liquid during passage of a plate 25 therethrough. Thus, in the operation of the quenching apparatus, the spray units 56 provide submerged curtains or sheets of quench liquid directed angularly into the liquid-filled channel 20 and impinging against the plate 25.

As a result of the angularly directed submerged sheets or curtains of quench liquid discharging into the full channel 20 at high velocity through the orifices 81, there is a tendency for air to be aspirated into the channel 20 through the plate inlet end of the quench apparatus. It has been found that the introduction of air into the channel 20 interferes with the desired uniform and rapid quenching action and must be avoided. To accomplish this result, a pair of sealing liquid supply chambers 92 are provided immediately upstream from the spray units 56. Each chamber 92 has a liquid inlet 93 and a narrow outlet slot 94 for directing a sheet of water or other quench liquid in a direction substantially normal to the longitudinal axis of the channel 20. Thus, the chambers 92 supply makeup or seal liquid in response to the aspirating effect induced by the angular injection of quench liquid through the slots 81 of the spray units 56 and thereby prevent the aspiration of air into the open plate inlet end of the channel 20. The chambers 92 are rigidly mounted against the upstream sides of the spray units 56 by means of straps 95 connected by screws 96 to the walls 58 of the spray units 56 and to the outer walls, designated at 97, of the chambers 92.

To further assist in the prevention of backflow of water or other quench liquid, a pair of rolls 98 are supported at the outer ends of pivot arms 99 supported on brackets 101 extending from the enclosures 26 and 27. The rolls 98 are yieldably urged toward each other by suitable resilient means (not shown) such as springs or fluid actuated cylinders coacting between the pivot arms 99. To facilitate the location of the rolls 98 as close as possible to the plate inlet end of the quench apparatus, the outer walls, designated at 102, of the sealing liquid supply chambers 92 are directed inwardly at an angle so that the chambers 92 have a generally triangular cross-sectional shape.

It will be understood that internal support rolls can be provided for the plates 25 instead of the threaded supports 24. In addition, to accommodate high speed travel of the plates, a plurality of quench devices 12-56-92 can be arranged in end-to-end relation with supporting rolls therebetween so that the plates can pass successively from one quench device to the next while being supported on the interposed rolls.

In the operation of the quench apparatus, a heated plate 25 passes from the furnace 11 between the rolls 98 into the quench channel 20, it being understood that the rolls 98 are spread apart to accommodate passage of the plate therebetween but are held in tight rolling engagement with the plate, thereby minimizing the tendency for water or other quench liquid to flow rearwardly into the furnace 11. Backflow of water is also undesirable from the viewpoint of effective quenching since it is highly desirable that the quenching be effected rapidly and entirely within the quench channel 20 while the steel plate is still substantially at its maximum temperature, thereby avoiding slack quenching. Thus, it is important that the furnace 11 be located closely adjacent the quench unit 12 and that the time of plate exposure between the furnace and the quench apparatus be as low as possible, e.g. less than 5 seconds.

The plate is moved through the quench channel 20 by conventional means (not shown) in a continuous movement and at a rate correlated with the cooling capacity of the apparatus so as to obtain the desired

quench. As the plate moves through the quench channel 20, it is supported on the adjustable plate supports 24 or other equivalent support means.

As previously mentioned, the volume flow rate of water or other quench liquid from the spray units 56 is sufficient to insure that the channel 20 is always full of liquid, and the plate is quenched by immersion in and passage through the concurrently moving body of liquid in the channel 20 which is continuously replenished by the angularly directed sheets of liquid from the orifices 81. The submerged sheets or curtains of liquid from the orifices 81 are impinged against the opposite surfaces of the plate 25, thereby insuring adequate turbulence at the surfaces of the plate to prevent the accumulation of steam or vapor barriers which would interfere with optimum quenching. The angular direction of the liquid sheets from the orifices 81 in combination with the high liquid flow velocity through the channel 20 insures unidirectional liquid flow toward the discharge tube 52 and avoids back flow. Although not essential in every case, the submerged jets of quench liquid from the openings 23 throughout the length of the quench channel 20 downstream from the orifices 81 further contribute to the maintenance of liquid turbulence at the plate surfaces and assist in the elimination of steam or vapor barriers. The sealing effect of the liquid introduced into the channel 20 through the slots 94 avoids the aspiration of air into the quench channel 20, thereby further insuring the desired maximum quenching effect.

The plate is removed through the discharge conduit 52, and the effluent quench liquid likewise flows out through the open discharge end of the conduit 52 where it may be collected in a suitable receptacle (not shown) for recirculation to the liquid inlets 49, 51, 61, and 93.

If necessary, the quenched plates may be rolled to improve their flatness and shape in a manner well known in the art.

Uniformity of quenching is essential not only for the sake of obtaining a quenched product having uniform microstructure and uniform physical properties but also to avoid or minimize warpage and distortion of the plate. Irregular vaporization of the water or other quench liquid in contact with the plate can result in substantial differentials in heat transfer rates between portions of the plate surface in contact with liquid and other portions in contact with vapor, thereby resulting in quenching stresses and deformation. However, in the quench system of the present invention the desired uniformity of quenching is realized as a result of several cooperating factors. The provision of the restricted quench channel 20 results in a quench liquid velocity relative to the plate 25 which is at least 10 ft./sec. in a direction concurrent with respect to the movement of the plate. Furthermore, the submerged spray units 56 are designed so as to contribute materially to the desired uniformity of quenching because of the ability of the spray units 56 to deliver relatively thin unitary sheets or curtains of quench liquid having uniform flow across the entire width of the quench channel and the plate being quenched. The submerged liquid sheets from the orifices 81 of the spray units 56 impinge against the opposite sides of the plate 25 causing turbulence at the plate surfaces thereby preventing accumulation of vapor. Moreover, the submerged liquid jets from the apertures 23, when the latter are provided, insure a condition of turbulence at the plate surfaces throughout the passage of the plate through the remainder of the quench channel. In addition, the avoidance of air aspiration into the quench liquid by means of the sealing liquid supply chambers 92 also contributes to the desired uniformity of quench action.

Another important advantage of the channel quench system of the present invention is that the system makes highly efficient use of the water or other quench liquid as compared with the spray quench systems heretofore used. Thus, water consumption is kept to a minimum. Within the broadest scope of the invention, any suitable quench liquid may be used including water, brine or other aqueous salt solution, oil, etc. However, an aqueous quench liquid will generally be most convenient, and for most favorable results the temperature of the inlet liquid should be not higher than about 75°F. Using an aqueous quench liquid, it is possible to achieve with the present invention a heat withdrawal flux density of from about 1,000,000 to about 10,000,000 B.T.U./hr. sq. ft.

Using water at 40°F. as the quench liquid in an experimental apparatus of the type illustrated in the drawings, it has been possible to quench both carbon-manganese and carbon-manganese-boron steel plates of seven-sixteenths and five-eighths inch thickness with very effective results. The carbon-manganese steel had a typical analysis, as follows (wt. percent):

| | |
|---|---|
| carbon | .20 |
| manganese | 1.14 |
| phosphorus | .016 |
| sulfur | .025 |
| silicon | .22 |
| aluminum | .044 |
| titanium | .003 |

The carbon-manganese-boron steel had a very similar analysis except for the inclusion of 0.001 wt. percent boron.

The plates were austenitized at 1,650°F. prior to quenching. The quenched seven-sixteenth inch plates had a microstructure which was substantially 100 percent martensitic for one-sixteenth inch depth and in excess of 90percent martensite at the center. In the five-eighths inch quenched plate, the carbon-manganese steel was at least 95% martensite for a depth of one-sixteenth inch, and the carbon-manganese-boron steel was substantially 100percent martensitic for one-eighth inch depth and in excess of 95percent martensite at the center. After tempering at 950°F. the quenched plates had excellent tensile and impact properties, as shown by the following typical results:

| | 7/16 inch C-Mn steel | 5/8 inch C-Mn-B steel |
|---|---|---|
| .2% Offset Yield Strength (lbs./sq.in. × 1000) | 106.8 | 119.6 |
| Tensile Strength (lbs./sq.in. × 1000) | 118.9 | 125.9 |
| % Elongation in 1" | 22 | 15.3 |
| % Reduction in Area | 68.9 | 50.7 |
| Hardness ($R_c$) | 24.5 | 27.5 |

The water consumption during the aforementioned tests was 15 to 20 gallons/sq. ft. of plate surface as compared with water consumptions two and three times as

great in typical spray type commercial plate quenching installations.

We claim:

1. Quench apparatus comprising conduit means defining a horizontally disposed restricted quench channel adapted to run full of quench liquid and adapted to have a work-piece and high velocity quench liquid passed concurrently therethrough from an inlet end to an outlet end thereof, a plurality of angularly disposed orifice means in said channel adjacent said inlet end for directing thin submerged sheets of quench liquid into said channel at an angle from the horizontal and in the direction of movement of the work-piece through said channel, and means for introducing sealing liquid to said channel upstream from said orifice means to avoid aspiration of air into said channel through said inlet end.

2. The apparatus of claim 1 further characterized by the provision of means for introducing additional quench liquid to said channel downstream from said orifice means.

3. The apparatus of claim 2 further characterized in that said last-named means comprises apertured wall portions in said channel for directing a multiplicity of liquid jets into said channel toward said work-piece.

4. The apparatus of claim 1 further characterized in that said orifice means are disposed at an angle of from about 5° to about 30° from the horizontal.

5. The apparatus of claim 4 further characterized in that said angle is about 10°.

6. The apparatus of claim 1 further characterized by being especially adapted for quenching a work-piece in the form of a plate or the like having opposite sides with longitudinal and transverse dimensions substantially greater than its thickness, said apparatus comprising horizontally disposed upper and lower walls defining a downstream portion of said channel, a pair of upper and lower submerged spray units disposed at the upstream ends of said walls and having said angularly disposed orifice means for directing angular sheets of quench liquid against the opposite sides of the work-piece passing through said channel, and a pair of upper and lower sealing liquid supply chambers disposed adjacent said spray units and having liquid outlets extending across said channel upstream from said orifice means.

7. The apparatus of claim 6 further characterized in that said upper and lower walls of said downstream portion of said channel are provided with a plurality of apertures, and upper and lower liquid supply means are provided for directing submerged jets of quench liquid from said apertures into said downstream portion of said quench channel.

8. The apparatus of claim 6 further characterized by the provision of a pair of sealing rolls disposed adjacent the inlet end of said channel and adjacent said supply chambers for sealingly engaging the opposite sides of the work-piece during entry into said channel.

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