Sept. 29, 1970 C. F. SCHRADER ET AL 3,531,334

QUENCH SYSTEM

Filed Oct. 10, 1966

2 Sheets-Sheet 1

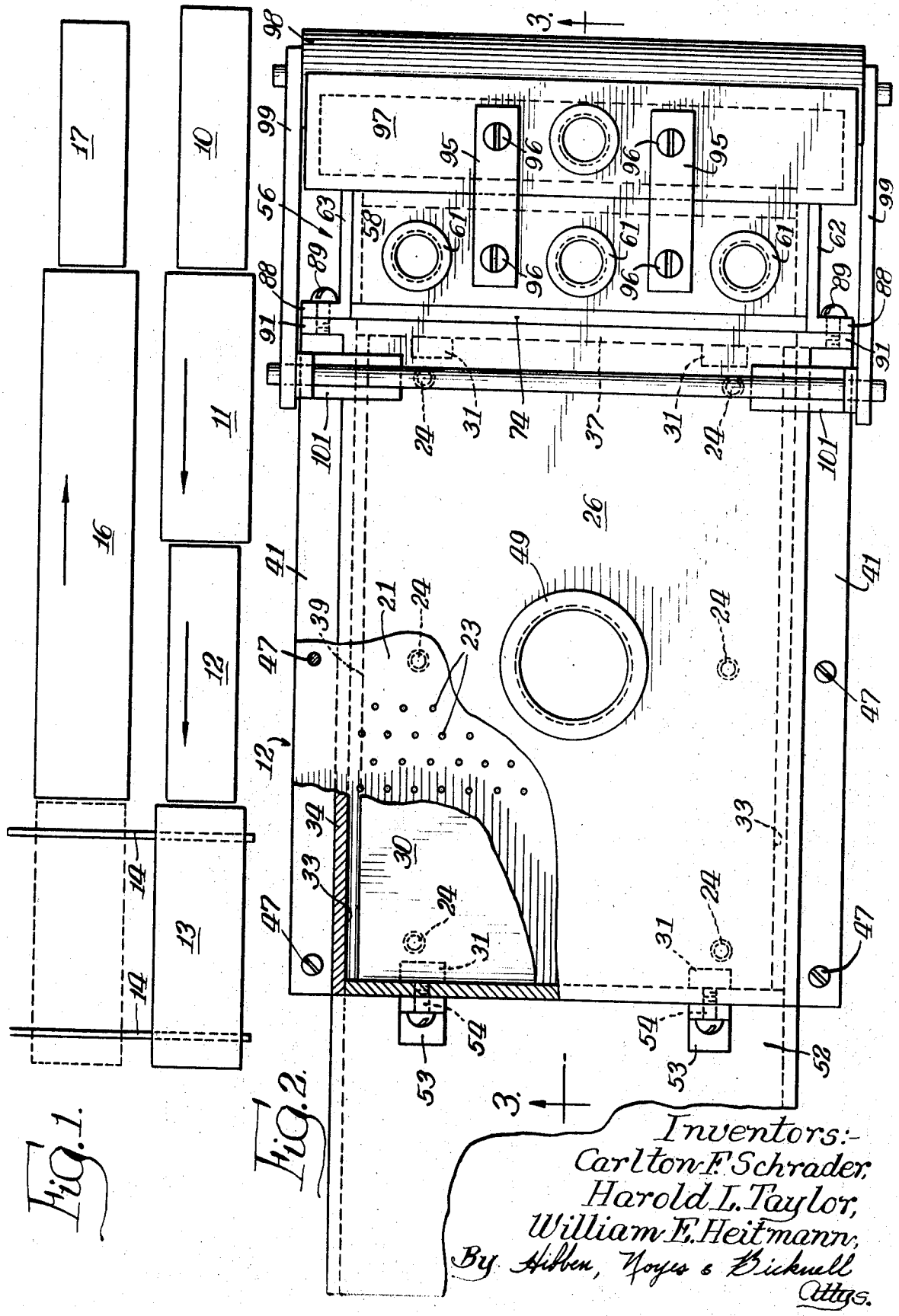


FIG. 1.

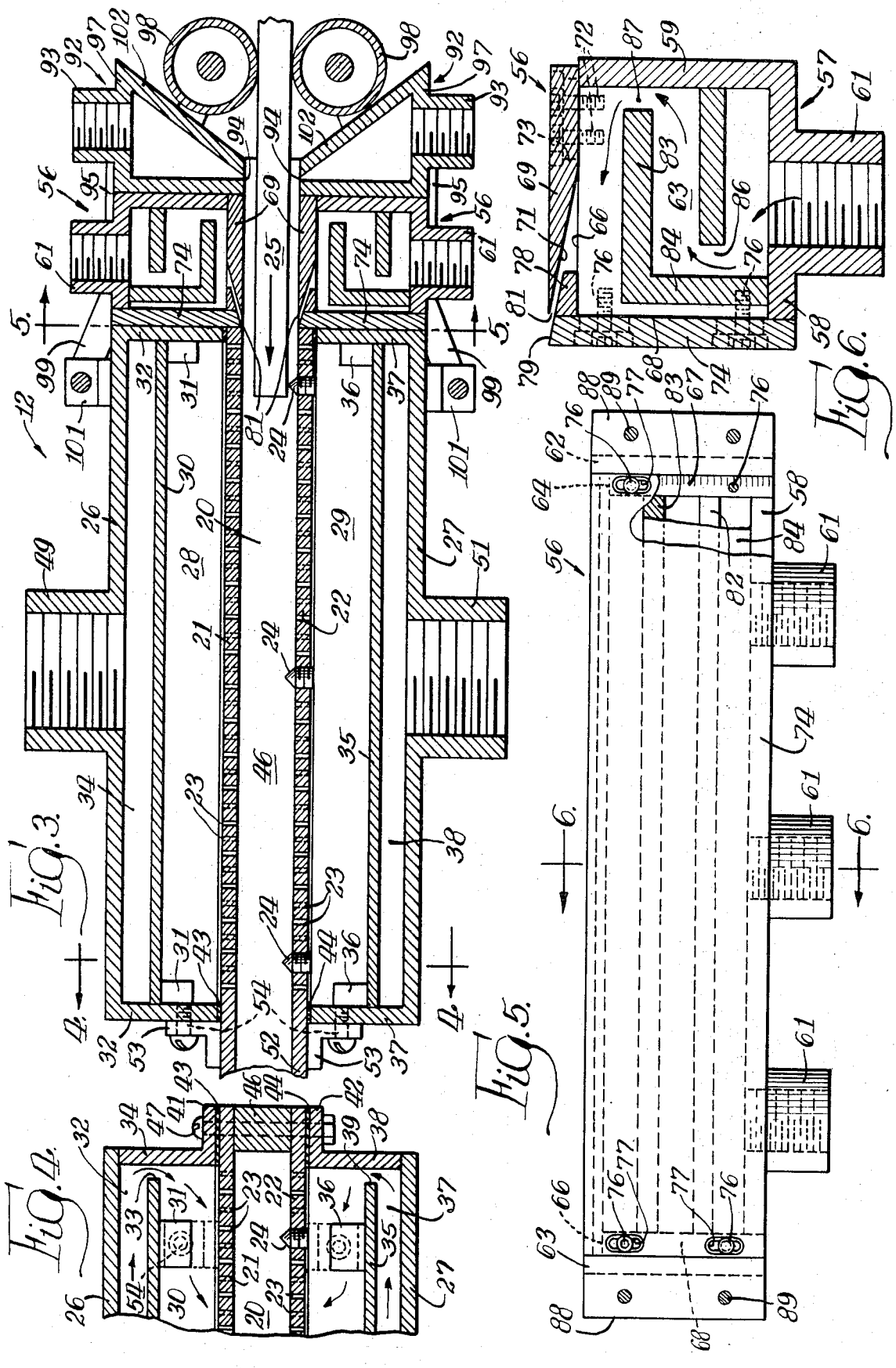
FIG. 2.

Inventors:-
Carlton F. Schrader,
Harold L. Taylor,
William E. Heitmann,
By Hibben, Noyes & Bicknell
Attys.

Sept. 29, 1970 C. F. SCHRADER ET AL 3,531,334

QUENCH SYSTEM

Filed Oct. 10, 1966 2 Sheets-Sheet 2



United States Patent Office

3,531,334
Patented Sept. 29, 1970

3,531,334

QUENCH SYSTEM

Carlton F. Schrader, Chesterton, and Harold L. Taylor, Hammond, Ind., and William E. Heitmann, Dolton, Ill., assignors to Inland Steel Company, Chicago, Ill., a corporation of Delaware

Filed Oct. 10, 1966, Ser. No. 585,516
Int. Cl. C21d 1/00
U.S. Cl. 148—153 7 Claims

ABSTRACT OF THE DISCLOSURE

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 directed 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.

This invention relates to a novel method and 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 end 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 are 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 plate 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 method and 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 .05 to .30 (preferably .15 to .20, particularly where superior weldability is desired); manganese .20 to 2.00 (preferably 1.10 to 1.35); phosphorus .04 max.; sulfur .04 max.; and the bal-

ance 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 .10 to .35 wt. percent and in some cases aluminum .02 to .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 .0005 to .006 (preferably, .001 to .002); nickel .50 to 2.00; chromium .50 to 2.00; molybdenum .10 to .50; and vanadium .02 to .25 (preferably, .06 to .08). The plate thickness may be from about ¼ 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 1525° F. to about 1850° 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 1250° 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 widths 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 wells **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 regulated 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 slots 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**, undesirable back flow of liquid is avoided. The dimensions of the channel **20** are restricted so 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 back flow 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 directly 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 five 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 7/16 and 5/8 inch thickness with very effective results. The carbon-manganese steel had a typical analysis, as follows:

	Weight 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 .001 wt. percent boron.

The plates were austenitized at 1650° F. prior to quenching. The quenched 7/16" plates had a microstructure which was substantially 100% martensitic for 1/16 inch, depth and in excess of 90% martensite at the center. In the 5/8 inch quenched plate, the carbon-manganese steel was at least 95% martensite for a depth of 1/16 inch, and the carbon-manganese-boron steel was substantially 100% martensitic for 1/8 inch depth and in excess of 95% 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.X1,000)	106.8	119.6
Tensile strength (lbs. sq.in.X1,000)	118.9	125.9
Percent elongation in 1"	22	15.3
Percent 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. A method of quenching a heated metal work-piece which comprises passing the work-piece horizontally through a restricted quench channel having an inlet end and an outlet end, introducing thin submerged sheets of quench liquid into said channel adjacent said inlet end, said liquid sheets extending across said channel transversely of the direction of movement of the work-piece therethrough and the volume flow rate of said liquid sheets being sufficient to maintain said channel filled with high velocity quench liquid flowing to said outlet end while said work-piece is passing therethrough, directing said liquid sheets against said work-piece at an angle of from about 5° to about 30° from the horizontal and in the direction of movement of the work-piece through said channel, the angular direction of said sheets and the high velocity of liquid flow through said channel substantially preventing back flow of liquid to said inlet end, and providing sealing liquid in said channel upstream from said liquid sheets in an amount sufficient to seal said inlet end of said quench channel and to avoid the aspiration of air.

2. The method of claim **1** further characterized by the step of introducing additional quench liquid to said channel downstream from said liquid sheets.

3. The method of claim **2** further characterized in that said additional quench liquid is introduced in the form of a multiplicity of submerged jets directed toward said work-piece to create turbulence at the work-piece surface.

4. The method of claim **1** further characterized in that said angle is about 10°.

5. The method of claim **1** further characterized in that said work-piece comprises a steel plate and the liquid flow velocity through said channel relative to said work-piece is at least about 10 feet per second.

6. The method of claim **1** further characterized in that said work-piece is a plate having opposite sides with longitudinal and transverse dimensions substantially greater than the thickness of the plate, a pair of said liquid sheets being directed against said opposite sides of said plate, and said sealing liquid being provided by a pair of streams at said opposite sides of said plate.

7. The method of claim **6** further characterized in that said sealing liquid is provided in the form of thin sheets extending transversely across said channel closely adjacent said inlet end.

(References on following page)

References Cited

UNITED STATES PATENTS

1,697,068	1/1929	Kenney	148—153 X
2,009,078	7/1935	Ziska	148—153
2,307,694	1/1943	Malke	134—122
2,542,237	2/1951	Dewey	134—122
2,657,698	11/1953	Garrett	134—122 X
2,658,012	11/1953	Strachan	148—153
2,893,409	7/1959	Wulf	134—122
2,900,992	8/1959	Johnson	134—122

RICHARD O. DEAN, Primary Examiner

U.S. Cl. X.R.

148—157