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Kranenberg et al.

[11] **3,889,507**

[45] **June 17, 1975**

[54] **APPARATUS FOR COOLING A STEEL MEMBER WHILE BEING ROLLED ON A CONTINUOUS HOT-ROLLING MILL**

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[73] Assignee: **Bethlehem Steel Corporation,** Bethlehem, Pa.

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[21] Appl. No.: **416,310**

[52] **U.S. Cl.** **72/201;** 266/65

[51] **Int. Cl.** **B21b 45/02**

[58] **Field of Search** .... 72/200, 201, 202, 236; 148/153, 156, 157; 266/4 S, 6 S

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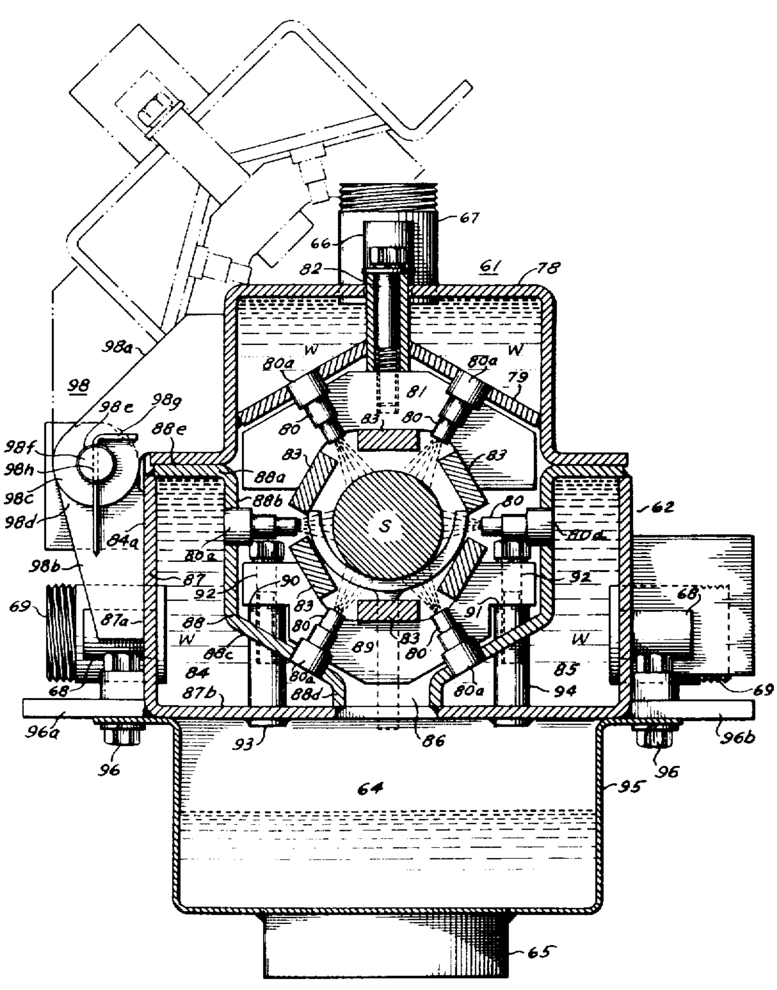
Primary Examiner—C. W. Lanham
Assistant Examiner—E. M. Combs
Attorney, Agent, or Firm—Joseph J. O'Keefe; Charles A. Wilkinson; John S. Simitz

[57] **ABSTRACT**

A spray unit positioned between roll stands in the path of a steel workpiece advancing in a predetermined substantially horizontal pass line in a continuous hot-rolling mill, includes a pair or spaced spray chambers longitudinally aligned in tandem. The steel workpiece passes through a spray section in each of the spray chambers. As the steel workpiece passes through the spray sections, water is sprayed by high pressure nozzles onto the entire surface of the steel workpiece to reduce the temperature thereof. Guard means are provided to prevent damage to the high pressure nozzles. The steel workpiece is aligned axially in the spray chambers by positioning means. The sprayed water is rapidly removed from the spray sections to prevent the formation of a water bath in the spray chambers.

8 Claims, 6 Drawing Figures



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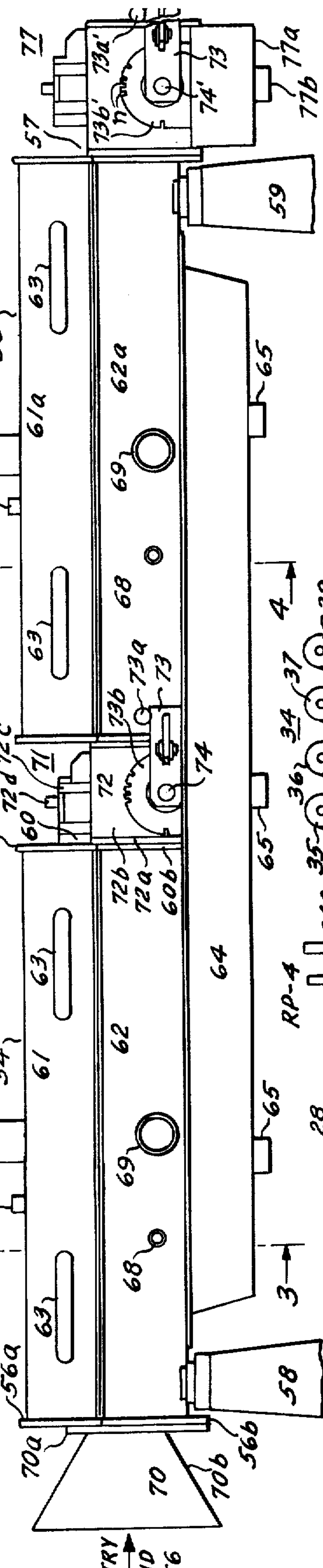


FIG. 2

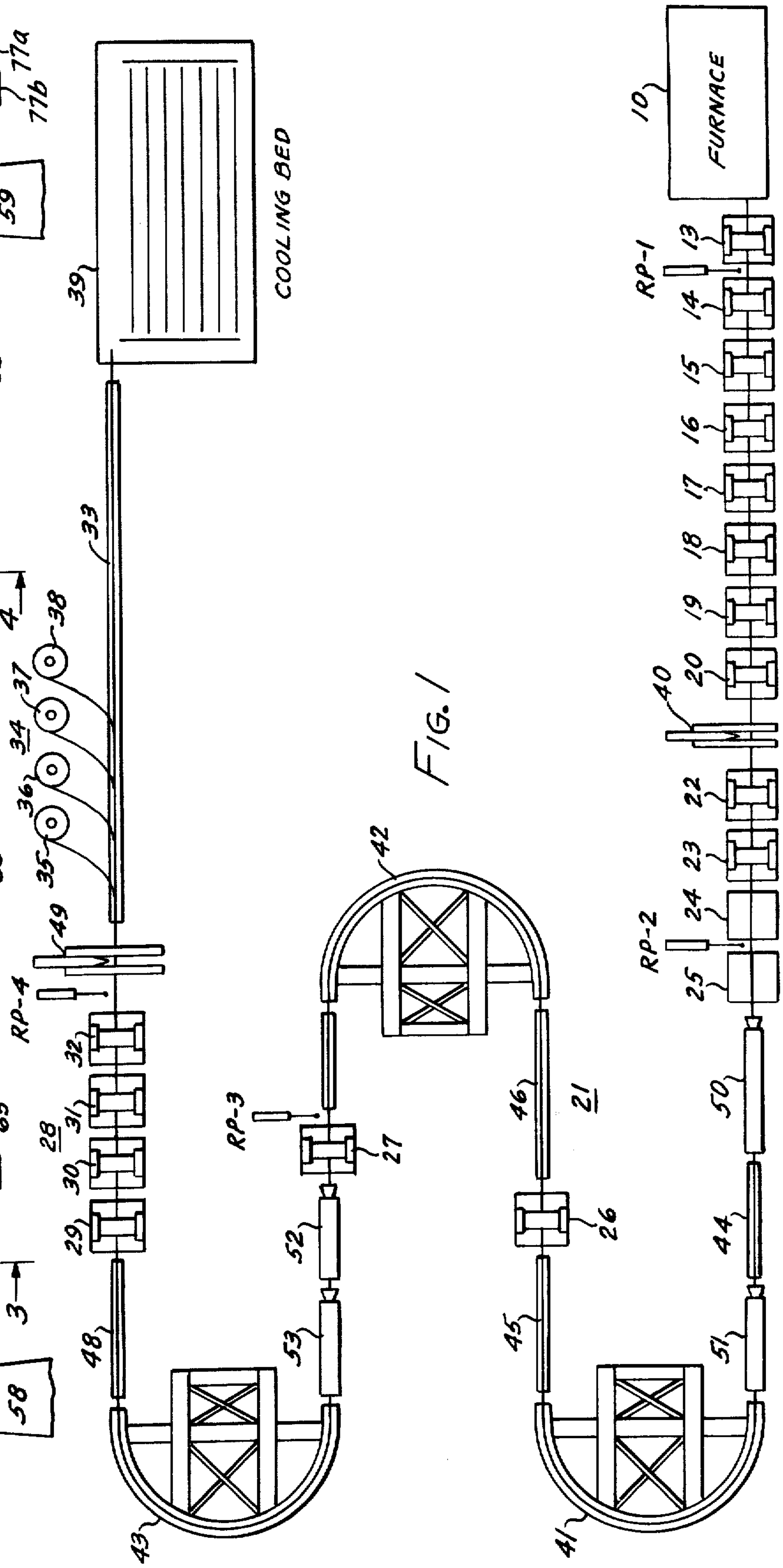
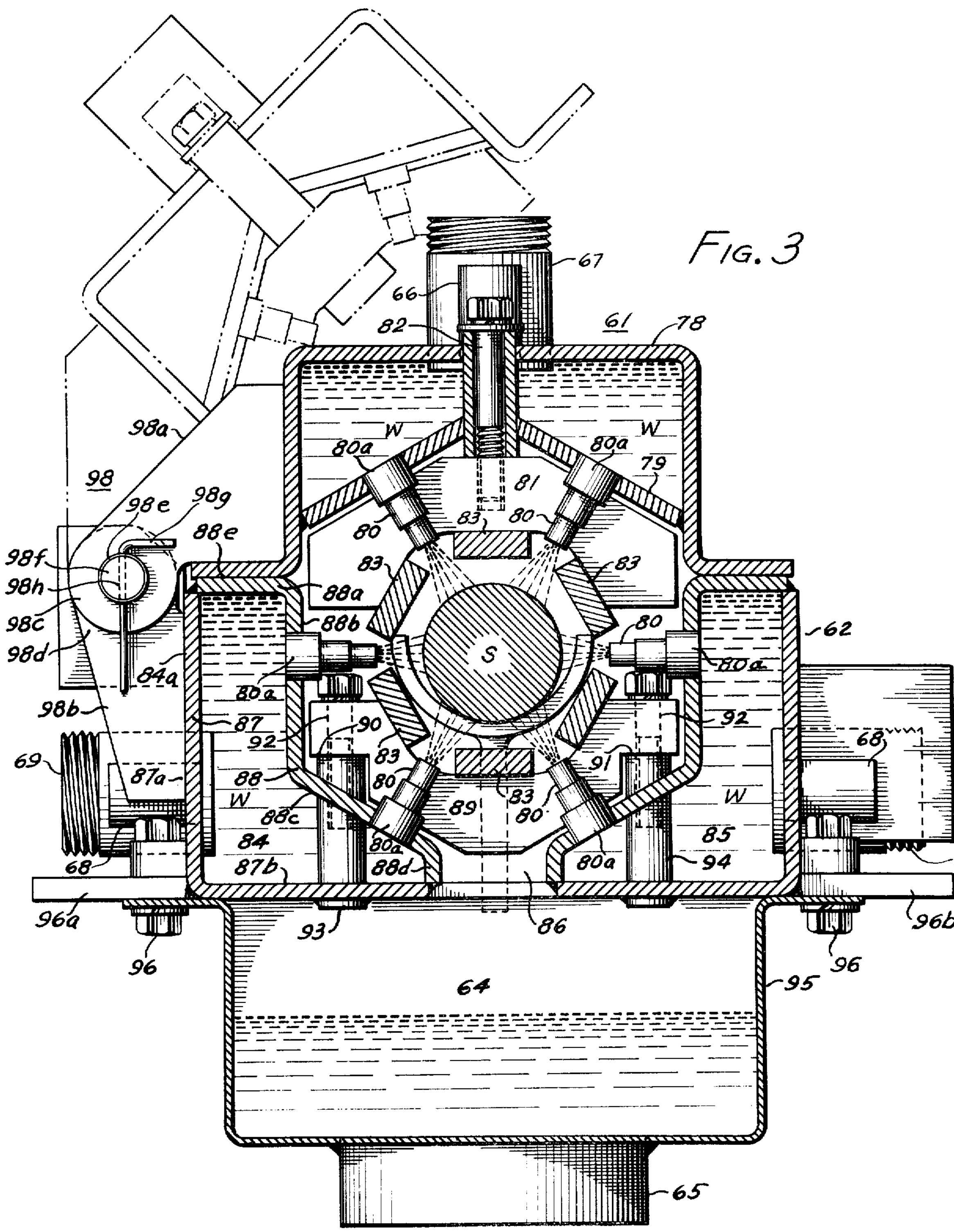


FIG. 1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80
80a
80a
84a
87
92
90
92
83
91
87a
88
83
W
W
80
89
80
88c
84
85
80a
80a
87b
88d
94
98a
98
98e
98g
98f
98h
98c
98d
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96a
93
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96b
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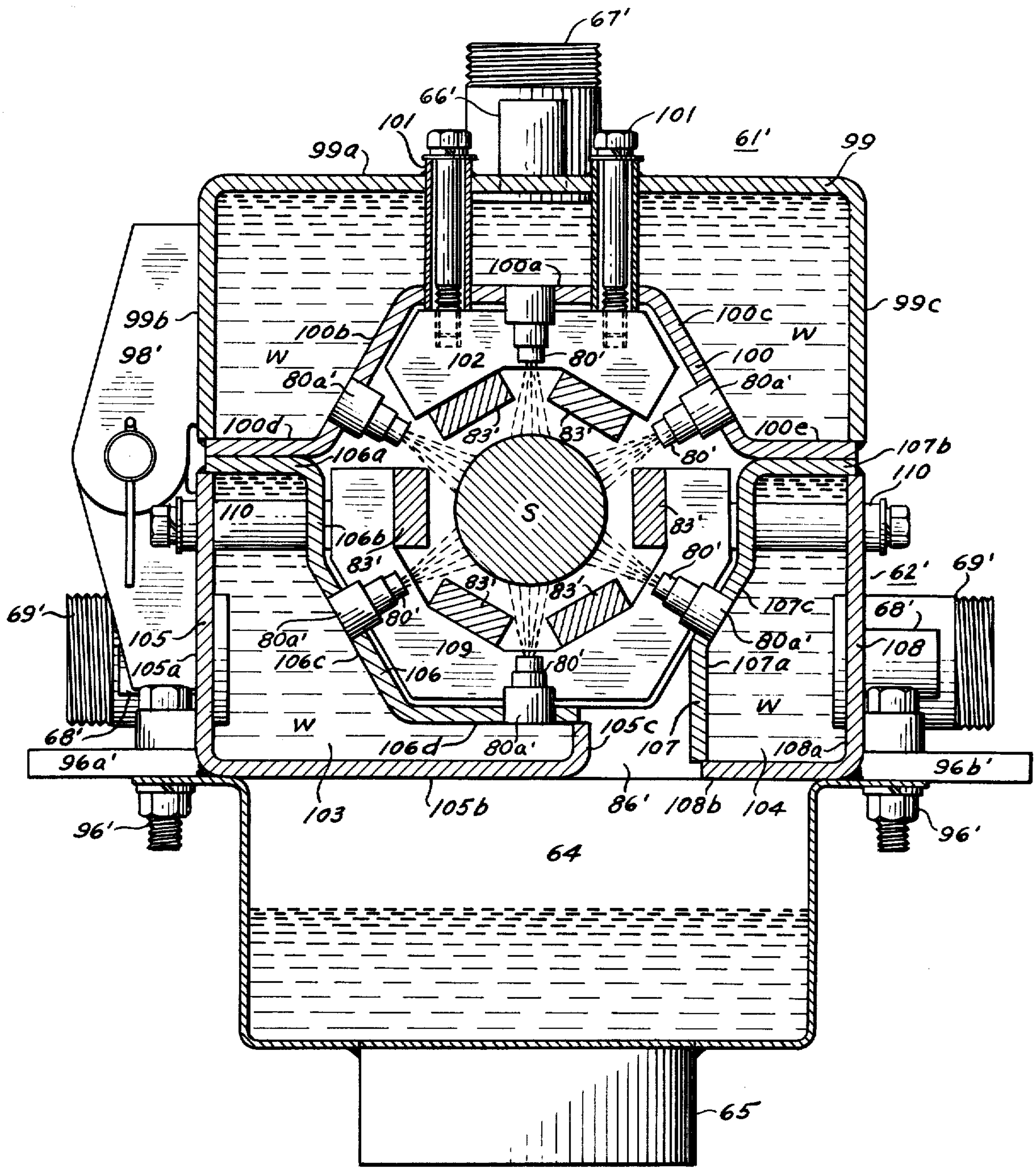
64
95
65
S

FIG. 3

FIG. 4


67'
66'
101
101
61'
99a
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99b
99c
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98'
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102
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80a'
80a'
83'
83'
100d
100e
106a
80'
107b
110
110
S
106b
83'
83'
80'
62'
69'
69'
80'
83'
83'
107c
68'
105
80a'
80a'
108
105a
106c
109
80'
107a
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W
68'
W
106d
80a'
105c
107
108a
96a'
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105b
86'
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104
96'
96'
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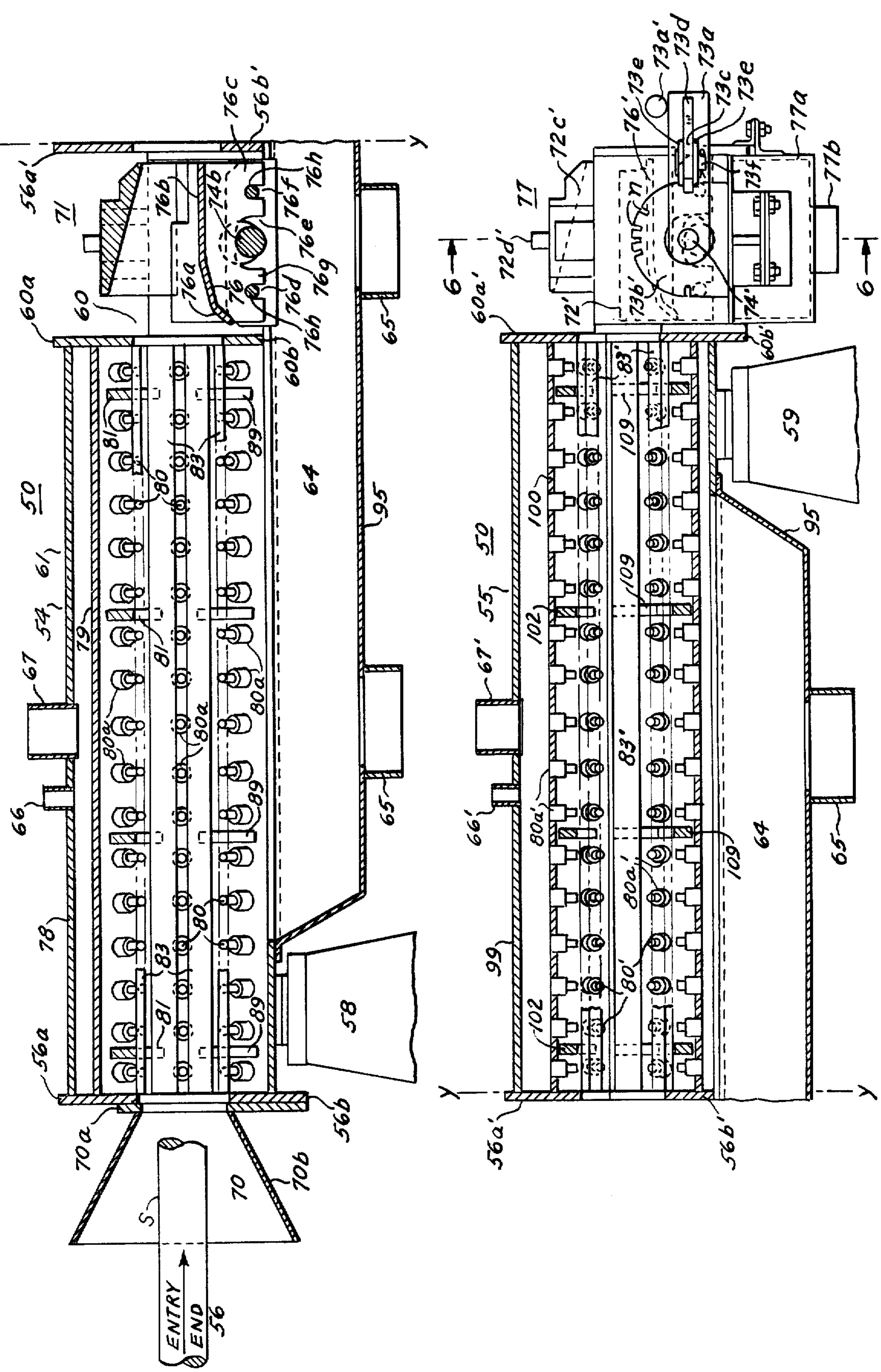
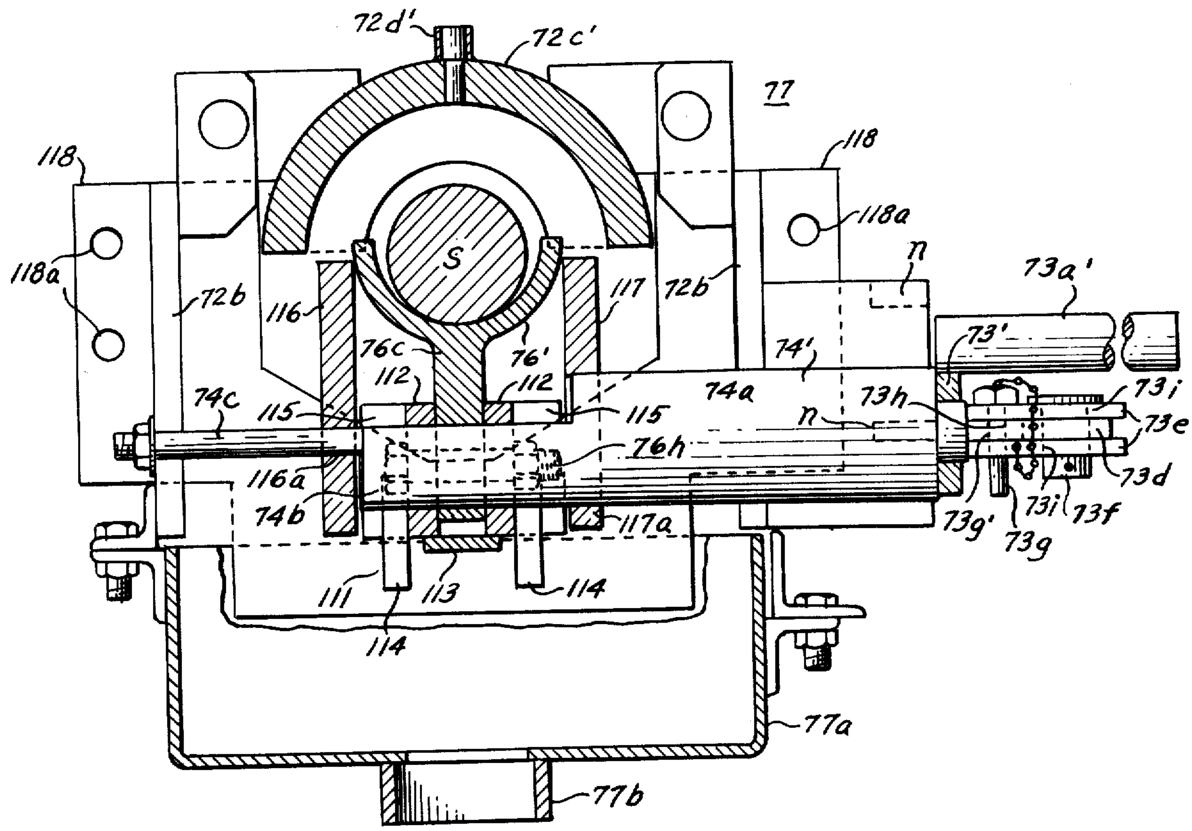


FIG. 5


72d'
72c'
77
118
118
118a
118a
72b
116
117
72b
n
73a'
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76c
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74'
73'
112
112
74a
73h
73i
74c
115
115
n
73e
76h
116a
73d
74b
117a
73g'
73i
73f
73g
111
113
114
114
77a
77b

FIG. 6

APPARATUS FOR COOLING A STEEL MEMBER WHILE BEING ROLLED ON A CONTINUOUS HOT-ROLLING MILL

BACKGROUND OF THE INVENTION

This invention is directed to apparatus for spraying water or other coolant onto the surface of a steel workpiece while the workpiece is being hot-rolled in a continuous hot-rolling mill to control the finishing temperature of the steel workpiece off-the-mill. The apparatus of the invention more particularly comprises a spray unit having a pair of spray chambers wherein spray means are used to spray water onto the surface of the steel workpiece as it passes through said spray chambers.

Steel products, such as bars and rods, are produced by hot rolling steel billets in a continuous hot-rolling mill, for example, a bar mill, a rod mill or the like. The hot rolled steel generally is finish rolled at temperatures of between about 1,950° to 2,100° F. and is then air-cooled to ambient temperature. During air-cooling a non-uniform, thick, coarse and sometimes blustery scale forms on the surface of the steel and the steel does not attain uniform metallurgical characteristics. All prior art processes to control the scale formation and to produce steel having uniform metallurgical characteristics have generally involved apparatus to treat the steel after it has been finish rolled but prior to air-cooling, as exemplified, for example, in U.S. Pat. No. 3,735,966 issued May 29, 1973 to Bernd Hoffmann and entitled "Method for Heat Treating Steel Wire Rod." Hot-rolled rod is passed in accordance with the disclosure of this patent through alternate quenching and heat compensating zones to cool the surface temperature of the rod to below about 400° C. (752° F.) subsequent to finish rolling and prior to coiling in flat overlapping wraps on a conveyor. The apparatus is comprised of water cooling units and air cooling units. The length of the water cooling units becomes shorter and the length of the air cooling units becomes longer in the direction of travel of the finished rod according to a logarithmic relationship.

U.S. Pat. No. 1,988,192 issued Apr. 16, 1935 to A. B. Haswell entitled "Means for Guiding and Cooling Rolled Metal" is directed to apparatus for guiding and cooling hot-rolled stock such as rounds, squares, strip and similar sections as the hot-rolled stock comes from the rolls of a rolling mill in a highly heated state. The apparatus comprises water boxes spaced above and below a passage for the steel. Steel members close the sides of the passage. The water-boxes are much larger than the passage to thereby prevent heating of the cooling water in the water-boxes. The water is fed into the passage from the water boxes by ports provided therein. The amount of water in the passage is sufficient to form a bath through which the steel passes.

Unfortunately, when steel at elevated temperatures comes into contact with water, a steam blanket forms around the steel. The steam blanket insulates the steel, preventing contact between water and steel. The cooling effect of the water is retarded if not altogether blocked. Passing the steel through a water bath is not an effective way to reduce the temperature of the steel.

It is the primary object of this invention to provide apparatus positioned between roll stands for spraying water onto the entire surface of a steel workpiece as it is being advanced in a continuous hot-rolling mill.

SUMMARY OF THE INVENTION

The apparatus of the invention is a spray unit which includes a pair of spaced spray chambers enclosing a portion of the pass line in a continuous hot-rolling mill and spray means in said spray chambers to spray a coolant onto the entire surface of a steel workpiece being hot-rolled. Guard means mounted on support means in said spray chambers protects the spray means from contact with the steel workpiece. Means for positioning the steel workpiece axially in said spray chambers is provided at the middle portion and exit end of the spray unit. The spray unit is mounted between the roll stands of a continuous hot-rolling mill.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatic plan view of the spray apparatus between roll stands in a continuous hot-rolling mill.

FIG. **2** is a view in elevation of the apparatus of the invention.

FIG. **3** is a cross-sectional view along **3—3** of FIG. **2.**

FIG. **4** is a cross-sectional view along **4—4** of FIG. **2.**

FIG. **5** is a longitudinal sectional view of the apparatus shown in FIG. **2.**

FIG. **6** is a cross-sectional view along **6—6** in FIG. **5** of a control box in the spray apparatus.

PREFERRED EMBODIMENT OF THE INVENTION

A steel workpiece which is being hot-rolled on a continuous hot-rolling mill, such as a bar mill, rod mill and the like, is cooled during hot-rolling by passing the steel workpiece through at least one spray unit mounted between roll stands in line with the predetermined substantially horizontal pass line defined by the roll passes in the roll stands of the mill. Water is sprayed onto the entire surface of the steel workpiece to cool the surface of the steel workpiece during hot rolling. The as-rolled product off-the-mill has an integrated mean temperature of not more than about 1,750° F. A diagrammatic plan view of a continuous hot-rolling mill and auxiliary equipment with spray units in position between roll stands of the mill is shown in FIG. **1.**

Turning now to FIG. **1**, the steel workpiece is heated to a rolling temperature within the range of about 1,950 ° to about 2,100° F. in a furnace **10** generally used for this purpose. The steel member is discharged from furnace **10** and is hot-rolled to finish size in mill **11** which comprises a roughing train **12** having roll stands **13, 14, 15, 16, 17, 18, 19** and **20**; an intermediate train **21** having roll stands **22, 23, 24, 25, 26** and **27**; finishing train **28** having roll stands **29, 30, 31** and **32**; a run-out table **33**; a coiling station **34** having coilers **35, 36, 37** and **38** and a cooling bed **39.** A flying shear **40** is provided between the roughing train **12** and intermediate train **21.** Repeaters **41** and **42** in the intermediate train **21** and repeater **43** between the intermediate train **21** and finishing train **28** are provided to loop the steel workpiece 180° during hot-rolling. Troughs **44,45,** 46 and 47 in the intermediate train 21 and trough **48** between repeater **43** and the finishing train **28** provide support for the steel workpiece as it passes through the mill **11.** A flying shear **49** after the finishing train **28** cuts the steel to length when required. Spray units **50** amd **51** in the intermediate train **21** and spray units **52** and **53** between the intermediate train **21** and finishing train **28** are used to spray water onto the surface of the steel workpiece as it is being hot-rolled to control the temperature of the steel workpiece.

In operation, the steel workpiece is passed from the furnace **10** to the mill **11** and passes progressively continuously through the roll stands **13, 14, 15, 16, 17, 18,** 19 and **20** in the roughing train **12.** The temperature of the steel workpiece is observed by use of radiation-type pyrometer RP–1 between roll stands **13** and **14.** A short portion of the front end of the steel workpiece is cropped by flying shear **40** as the steel workpieces passes between roll stand **20** and the first roll stand **22** of the intermediate train **21.** The steel workpiece continues through the roll stands **22, 23, 24, 25, 26** and **27** of the intermediate train **21.** Roll stands **24** and **25** appear as dummy stands in FIG. **1**, that is, there are no rolls in the roll stands and hence the steel workpiece is not reduced in cross-sectional area as it passes through these stands. However, dependent upon the size of steel workpiece being hot-rolled and the desired finish size, the stands can be equipped with matches rolls to also reduce the cross-sectional area of the steel workpiece during its passage through these stands. The temperature of the steel workpiece is taken by a radiation-type pyrometer, RP–2, as it passes between roll stands **24** and **25.** As the steel workpiece passes through the intermediate train **21**, it is looped 180° by repeaters **41** and **42.** Of course, the steel workpiece can be hot-rolled in an in-line continuous hot-rolling mill which does not require the use of repeaters. As the steel workpiece passes through the intermediate train **21**, the steel workpiece passes through spray units **50** and **51** located between roll stands **25** and **26.** Water is sprayed onto the surface of the steel workpiece as it passes through the spray units **50** and **51.** The flow of water in each spray unit in the mill is controlled to start after the leading end of the steel workpiece has passed through the spray unit to prevent hardening of the leading end of the steel workpiece and thereby prevent marring or spalling of the surface of the work rolls in the roll stands which could occur as the steel workpiece enters the roll passes in the roll stands. The steel workpiece is supported by trough **44** as it passes between first spray unit **50** and second spray unit **51.** The steel workpiece is looped 180° in repeater **41** and is supported by trough **45** as it passes to roll stand **26.** Trough **46** supports the steel workpiece as it passes to repeater **42** where the steel workpiece is again looped 180° and is passed to roll stand **27** which is the last roll stand in the intermediate train **21.** The temperature of the steel workpiece is again taken by a third radiation-type pyrometer, RP–3, prior to rolling in roll stand **27.** After the steel workpiece passes from the intermediate train **21** it passes through spray units **52** and **53** arranged in tandem. The steel workpiece is again looped 180° in repeater **43**, passes through trough **48** and is rolled to a desired finish size in roll stands **29, 30, 31** and **32** of the finishing train **28.** A flying shear **49** after roll stand **32** cuts the steel workpiece to the desired length. The temperature of the steel workpiece is again taken by a radiation-type pyrometer, RP–4, as it leaves the last roll stand **32** in the finishing train **28.** If it is desired to coil the steel workpiece, it is passed to one of coilers **35, 36,** 37, 38 in coiling station **34.** If straight bars are being produced, the steel workpiece is passed to the run-out table 33 and then to cooling bed **39.** In either case, the steel workpiece is air-cooled to ambient temperature after finish rolling.

We have found that by hot-rolling the steel workpiece as described above, the temperature of the surface of the steel workpiece off-the-mill is controlled to about 1,740° F. for finished bars and rods having a diameter of one-half of an inch, and preferably not more than about 1,700° F. for finished bars and rods having large diameters. The integrated mean temperature of the steel workpiece off-the-mill is not higher than about 1,750° F. A steel workpiece hot-rolled in the conventional manner, that is, wherein the steel workpiece is not water sprayed during rolling, has a surface temperature of between about 1,900° and 2,100° F. and an integrated mean temperature of about 1,950° F. or higher.

Since spray units **50, 51, 52** and **53** are identical, we will describe only spray unit **50.** Referring now to FIG. **2**, the spray unit **50** includes a pair of spray chambers **54, 55** aligned longitudinally in tandem in line with the predetermined substantially horizontal pass line of the steel workpiece as it passes through the mill. The spray unit **50** has an entry end **56** and an exit end **57.** The entire spray unit **50** is supported by stands **58, 59** which can be of any suitable material, such as reinforced concrete, steel structural framework and the like. Spray chambers **54** and **55** are substantially the same. Therefore only spray chamber **54** will be described in detail. Identical numbers will be used to identify identical parts of each spray chamber. Spray chamber **54** has an entry end **56**, which is also the entry end **56** of the spray unit **50**, and an exit end **60.** The spray chamber **54** comprises a cover **61** shown contiguous with a bottom portion **62** as described hereinafter and shoen in FIG. **3.** The ends **56** and **60** are made watertight by welding metallic plates ***56a*** and ***56b***, ***60a*** and ***60b*** to the cover **61** and bottom portion **62**, respectively. The cover **61** can be pivotally lifted manually from the bottom portion **62** by means of handles **63.** An elongated water collecting and disposal trough **64** is fastened to bottom portion **62** and extends substantially the length of the spray unit **50.** A plurality of outlet pipes **65** extend downwardly from the bottom of the trough **64** and communicate therewith by means of ports (not shown), which allow the rapid removal of water to waste or to storage. The cover **61** and bottom portion **62** are provided with a plurality of inlet pipes, **66, 67,** and **68, 69** respectively whereby water under pressure, for example, about 25 pounds per square inch gage to about 60 pounds per square inch gage, is pumped therein. Although water under a gage pressure of 25 pounds per square inch can be used to advantage, we prefer to use water having a gage pressure of 35 pounds per square inch. A bell or guide cone assembly **70** comprises a base plate ***70a*** integral with a guide cone ***70b***. The guide cone assembly **70** is attached to the end plate ***56b***, for example, by bolt and nut assemblies (not shown) and guides the steel workpiece axially into the spray chamber **54.** The spray chambers **54** and **55** are spaced a distance apart. A first control box **71** is provided in the space between spray chambers **54** and **55** to provide means interiorly (hereinafter described) for positioning the steel workpiece axially in conjunction with a second control box **77** in the spray unit **50.** The control box **81** has a box-like exterior housing **72** having end plates ***72a*** and side plates ***72b***. A control arm **73** is rotatably attached to a shaft **74.** A control handle ***73a*** on control arm **73** provides means to rotate control arm **73** through 180°. A semicircular locking hub ***73b*** positioned between the control arm 73 and side plate 72*b* provides means for locking a positioning funnel (shown in FIG. 3 and identified as 76) in a desired position interiorly in the control box 71. A guard cone 72*c* is provided atop the housing 72 to prevent the steel workpiece from passing upwardly and straying from the pass line of the mill when passing from spray chamber 54 to spray chamber 55. A water inlet pipe 72*d* atop the guard cone 72*c* allows water to be passed downwardly through the control box 71 to prevent over-heating of the metallic parts interiorly the control box 71. The control box 71 is secured to end plates 60*b* and 56*b'* by any means, for example, welding. Control box 77 is attached by any means, for example, welding, to the end plate 60*b'*.

Turning now to FIG. 3, which is a cross-sectional view of spray chamber 54, along line 3—3 in FIG. 2, the cover 61 is an elongated box-like watertight header, fabricated in the shape shown from two metallic plates 78 and 79. The two metallic plates 78 and 79 are welded together to form the watertight structure shown. Water W is pumpled into header 61 by means of two inlet pipes 66 and 67. Plate 79 is provided with ports (not shown) wherein couplings 80*a* are fixedly attached. High pressure nozzles 80 are threaded into the couplings and communicate with the interior of header 61. The high pressure nozzles 80 spray water in a fan-shaped jet. An angle $\phi 70°$ defines the extent of the jet. The fan-shaped jet defines a substantially steaight line on the surface of the steel workpiece which is impinged by the jet. The fan-shaped water jet is formed by a generally oval opening in each nozzle 80. The nozzles 80 in the spray chambers 54, 55 are positioned in the header in a manner such that the fan-shaped jet is at an angle of 20° to the axis of the steel workpiece. By positioning the nozzles 80 in this manner the substantially straight line impinged on the surface is made wider and a larger surface area of the steel workpiece is impinged by the fan-shaped jet than if the oval opening is positioned parallel to the axis of the steel workpiece. In the latter position, non-uniform cooling of the surface of the steel workpiece would occur. Two horizontal lips 78*a* and 78*b* are formed in plate 78.

A downwardly open yoke 81 is fastened to the header 61 by fastening means, for example, a sleeve and bolt combination 82, extending downwardly through two ports (not shown) in the header 61. A plurality of the yokes 81 spaced a distance apart are provided along the length of the chamber 54. A plurality of spaced buard bars 83, generally rectangular in cross-section, are attached, for example, by welding, to each of the yokes 81 and extend longitudinally and substantially the length of the header 61. It must be understood that the yokes 81 can be other geometric shapes, such as a semi-circle, other polygonal shapes and the like. Likewise, the guard bars 83 can be of any shape in cross-section, for example, square, rectangular, triangular, and the like. The guard bars 83 protect the high pressure nozzles 80 from damage by the passing steel workpiece S particularly in the case of a cobble or by the leading edge (not shown) of the steel workpiece S as it passes through the spray chamber 54.

The bottom portion 62 of the spray chamber 54 comprises two elongated box-like headers 84 and 85 which are fabricated in the shapes shown and are watertight. The headers 84, 85 are mirror images of each other and are in longitudinally spaced parallel relationship to each other. The space between and defined by the headers 84, 85 is an elongated slot 86 extending the length of the spray chamber 54. Since the headers 84, 85 are mirror images of each other, only header 84 will be described, and similar parts of the headers 84, 85 will be identified with the same numerals. Header 84 is fabricated from two metallic plates 87, 88 in the shape shown. Header 84 can best be described as generally being an open L in shape. The open L is formed by an outer vertical leg 87*a* and a horizontal base 87*b* formed by plate 87 and an inner generally horizontal lip 88*a*, a vertical leg 88*b* perpendicular to the lip 88*a*, and a generally sloping lower leg 88*c* extending from leg 88*b* to a short vertical leg 88*d*. The lip 88*a* is parallel to base 87*b* and is welded to the upper edge of leg 87*a*. The leg 88*d* is parallel to leg 87 *a* and is welded to the base 87 *b* to make a watertight container. End plates (not shown) are welded to each end of the header 84 to make a watertight container. The horizontal lip 88*a* provides a surface 88*e* which is contiguous with lip 78*a* when the cover 61 is placed atop the bottom portion 62 to form a closure through which the steel workpiece S passes. When the cover 61 is closed atop bottom portion 62 a spray section A is formed which encloses a portion of the substantially horizontal pass line of the mill. The vertical leg 88*b* and the sloping leg 88*c* are provided with ports (not shown) wherein couplings 80*a* are fixedly attached. High pressure nozzles 80 are threaded into the couplings and communicate with the interior of the header 84. Water having a gage pressure of betwen about 25 pounds per square inch, but preferably 35 pounds per square inch, to 60 pounds per square inch is pumped into the header 84 through two inlet pipes 68, 69 extending horizontally inwardly through ports (not shown) in the vertical leg 87*a*.

An upwardly open yoke 89 having bosses 90 and 91 is fastened by means, for example, bolts 92, to supports 93 and 94 welded to the base 87*b* and extending upwardly into the bottom portion 62. The yoke 89 can have other geometric shapes, for example, any type of polygon, circular and the like. A plurality of elongated spaced guard bars 83 are attached, for example, by welding, to a plurality of yokes 89 spaced longitudinally in the spray chamber 54. The guard bars 83 extend the length of the spray chamber 54. While shown as being generally rectangular, the guard bars 83 can be any shape, for example, square, triangle, and the like.

The collecting and disposal means 64 is an elongated generally U-shaped trough fabriacated from metallic sheet 95 in the shape shown. The trough is fastened to the spray unit 50 by means, for example, bolt and nut assemblies 96 passing through lips 96*a* and 96*b* attached to the bottom portion 62, for example, by welding. Water is discharged from the trough 64 through outlet pipe 65 which communicates with the trough 64 through a port (not shown).

A vertically movable positioning funnel (shown in FIG. 5 and identified as 76) positions the steel workpiece S axially in the spray unit 50. The positioning funnel 76 in conjunction with a second positioning funnel 76' (FIG. 5) at the exit end 57 supports the steel workpiece S as it passes through the spray unit 50. The guide cone assembly 70 in FIG. 2 guides the steel workpiece S axially into the spray unit 50 but does not support the steel workpiece S as it passes through the mill.

The header **61** (shown in the open position in phantom) is pivotally attached to the bottom portion **62** by a hinge assembly **98** comprising a pair of metallic brackets **98***a* and **98***b* which are fastened by suitable means to the back walls **61***a* and **84***a* of the header **61** and header **84**, respectively. Each of the brackets **98***a* and **98***b* is provided with a hub **98***c* and **98***d*, respectively. The hubs **98***c* and **98***d* have an aperture **98***e* therein. When assembled, the hubs **98***c* and **98***d* overlap so that the apertures **98***e* are aligned. A smooth bearing type rod **98***f* is inserted into the apertures **98***e* so as to hold the brackets **98***a* and **98***b* together in pivoted relationship. Removable L-shaped pins **98***g* are inserted into passages **98***h* on either side of the brackets **98***a* and **98***b* in the rod **98***f* to prevent accidental removal of rod **98***f*. Only one L-shaped pin and aperture are shown.

When the header **61** is contiguous with the bottom portion **62**, that is, lips **78***a* and **78***b* are contiguous with lips **88**, a generally cylindrical spray section A is formed wherein the steel workpiece S passes through the spray unit and is sprayed with water. The high pressure nozzles **80** form a generally annular configuration and are spaced about 60° apart.

The spray chamber **55** of the spray unit **50** is shown in FIG. **4** which is a cross-sectional view taken along the line **4**—**4** of FIG. **2**. The header **61'** is fabriacted from metallic plates **99** and **100** to form a header **61'** in the shape shown. Metallic plate **99** is generally U-shaped having a horizontal base **99***a* and two downwardly extending legs **99***b* and **99***c*. Metallic plate **100** has a horizontal base section **100***a*, two downwardly and outwardly extending legs **100***b* and **100***c* and horizontal arms **100***d* and **100***e* extending horizontally outwardly from the legs **100***b* and **100***c*, respectively. The extremities of the arms **100***d* and **100***e* are welded to the extremities of the legs **99***b* and **99***c* respectively to form a watertight header **61'**. A plurality of ports (not shown) are provided in the base **100***a* and the legs **100***b* and **100***c* wherein couplings **80***a* are fixedly attached. High pressure nozzles **80'** are threaded into the couplings **80***a* and communicate with the interior of the header **61'**. Water W having a gage pressure of between 25 pounds per square inch, and preferably 35 pounds per square inch, to about 60 pounds per square inch is pumped into the header **61'** by conventional pumping equipment (not shown) through inlet pipes **66'** and **67'**. The water is sprayed onto the surface of steel workpiece S passing through spray section A' of the spray chamber **55** which is in line with spray section A in spray chamber **54**. The high pressure nozzles **80'** form a similar spray as described previously. The high pressure nozzles **80'** are annularly positioned 60° apart. Aligned ports (not shown) are provided in the base **99***a* and **100***a* whereby fastening means **101**, for example, a sleeve and bolt assembly, are used to support a downwardly open yoke **102** of the shape shown. A plurality of guard bars **83'** are fixedly attached to the yoke **102**, for example by welding. The guard bars **83'** prevent damage to the high pressure nozzles **80'** by cobbles or from the leading edge of the steel workpiece S as it passes through the spray chamber **55**. As noted previously, the shape of the guard bars **83'** is generally rectangular, but any shape can bee used.

The bottom portion **62'** comprises two headers **103** and **104** fabricated from metallic plates **105, 106** and **107, 108,** respectively, in the shapes shown. Header

103 can be described as having an open elongated L shape. The open L shape is formed by an outer vertical leg **105***a* and a horizontal base **105***b* perpendicular to leg **105***a*, a short vertical leg **105***c* formed from plate **105** and a horizontal lip **106***a*, a short vertical leg **106***b*, a sloping portion **106***c* and a horizontal base **106***d* formed from plate **106**. The extremity of lip **106***a* is welded to the upper surface of leg **105***a* and the horizontal base **106***d* is welded to vertical leg **105***c* to form a watertight closure. End plates (not shown) are welded to each end of the header **103** to form a watertight container. Sloping portion **106***c* and horizontal base **106***d* are provided with ports (not shown) whereby couplings **80***a'* are fixedly attached. High pressure nozzles **80'** are threaded into the couplings **80***a'* and communicate with the interior of the header **103**. Header **104** is formed by joining two metallic plates **107** and **108** which have two generally vertical legs **107***a* and **108***a* and two horizontal bases **107***b* and **108***b*. Vertical leg **107***a* has a sloping section **107***c* provided with a port (not shown) wherein a coupling **80***a'* is fixedly attached. A high pressure nozzle **80'** is threaded into the coupling **80***a'* and communicates with the interior of header **104**. Vertical leg **107***a* is welded to horizontal base **108***b*, and horizontal base **107***b* is welded to vertical leg **108***a* to form a watertight closure. End plates (not shown) are welded to either end of header **104** to make a watertight container. Water under a gage pressure of 25 pounds per square inch, and preferably 35 pounds per square inch, to 60 pounds per square inch is introduced into header **103** through inlet pipes **68'** and **69'** and into header **104** through inlet pipes **68'** and **69'**.

An upwardly opening yoke **109** of the shape shown is attached to the bottom portion **62'** by fastener means **110**, for example, a sleeve and bolt assembly, extending through ports (not shown) provided in headers **103** and **104**, respectively. A plurality of spaced guard bars **83'** are fixedly attached to the yoke **109**.

The headers **103** and **104** are spaced a distance apart and form an elongated longitudinal slot **86'** whereby the water after being sprayed onto the steel workpiece S can freely pass out of the spray section A', formed when header **61'** is contiguous with bottom portion **62'**, to the collecting and disposal trough **64** which is attached to the bottom portion **62'** of the spray unit **50** by fastening means **96'** and **96'** passing through lips **96***a'* and **96***b'*. The water passes from trough **64** to waste by means of outlet pipe **65**.

The header **61'** is pivotally attached to the bottom portion **62'** by identical hinge assembly **98'** used in spray chamber **54** and which was previously described.

When the header **61'** is in the operating position the high pressure nozzles **80'** form a generally annular configuration and are spaced about 60° apart. The high pressure nozzles **80'** are not aligned with the high pressure nozzles **80** in the spray chamber **54** but are rotated about 30° therefrom to thereby give a simulated rotation effect to the steel workpiece S as it passes through the spray unit **50** and to assure that the entire surface of the steel workpiece S is sprayed with water. The use of two spray chambers in tandem provides a thorough force cooling of the entire surface of the workpiece.

FIG. **5** is a longitudinal sectional view of the paired spaced spray chambers **54** and **55** longitudinally in tandem of the invention. The spray chamber **54** is provided with a guide cone assemply **70** as previously described at the entry end **56** of the spray unit **50** to guide the steel workpiece S axially into the spray section A. The steel workpiece S proceeds axially through the spray chamber **54** to a first control box **71** wherein steel workpiece S is guided axially by positioning funnel **76** into spray chamber **55.** The steel workpiece S travels axially through spray chamber **55** and leaves at the exit end **57** of the spray unit **50** through a second control box **77.** The positioning funnel **76'** in the second control box **77** guides the steel workpiece S axially out of the spray unit **50** and keeps the steel workpiece S in the substantially horizontal predetermined pass line of the mill. As the steel workpiece S passes through the spray unit **50,** the water is sprayed onto the surface thereof by means of a plurality of high pressure nozzles **80** and **80'** which are in a generally annular configuration as shown in FIGS. **3** and **4.** The annular configurations are spaced a distance apart and extend the length of each of the spray chambers **54** and **55.** A plurality of longitudinally extending guard bars **83** and **83'** fixedly attached to yokes **81, 89** and **102, 109,** respectively, to guard the high pressure nozzles **80** and **80'** from damage which can occur because of cobbles or from contact with the leading edge of the steel workpiece S as it passes through the spray unit **50.** In operation, the nozzles **80** and **80'** are not activated until the leading edge of the steel workpiece S has passed through the spray unit **50** to thereby prevent hardening of the leading edge of the steel workpiece. Spraying the leading edge with water would harden the leading edge and damage could occur to the rolls when the leading edge enters the roll pass between the rolls. The collecting and disposal trough **64** described previously and shown in cross-section in FIGS. **3** and **4** extends substantially the length of the spray unit **50.**

The control boxes **71** and **77** are identical. To fully describe the control boxes **71** and **77** we have shown control box **71** in longitudinal section and control box **77** in a plan view in elevation of the exterior in FIG. **5.** Turning now to the control box **77,** a control arm **73'** is fixedly attached to a longitudinal shaft **74'** extending through the control box **77.** A control handle **73*a*'** is provided on control arm **73'** whereby the control arm **73'** can be rotated about shaft **74'** for a distance of 180°. A slot **73*c*** is cut in control arm **73'**. a generally L-shaped lever **73*d*** is pivotally mounted between two parallel ears **73*e*** welded to control arm **73'** so as to pass through the slot **73*c*.** *The lever* **73*d*** pivots on a short headed pin **73*f*** which is passed through apertures **73*i*** in the ears **73*e*.** As shown in FIG. **6,** a locking pin **73*g*** chained to one of the ears **73*e*** is passed through aperture **73*h*** in the lever **73*d*** and apertures **73*i*** in the ears **73*e*** to lock the lever **73*d*** in place in any of the notches N provided in the hub **73*b*'** as described below. A generally semicircular hub **73*b*** having a plurality of predetermined radially disposed notches N is mounted between the housing **72'** of the control box **77** and the control arm **73'**. The notches N are placed so that when control arm **73'** is rotated about shaft **74'** a positioning funnel **76'** interiorly the control box **77** is raised or lowered. The lever **73*d*'** can be inserted into one of the notches N to thereby lock the positioning funnel **76'** into the proper position so that the steel workpiece S will be positioned axially in the spray unit **50.** A cone-shaped guard **72*c*'** is provided over the control box **77** to prevent the steel workpiece S from passing outwardly from the pass line of the mill as it passes from chamber **54** to spray chamber **55.** A water inlet pipe **72*d*'** allows water to be passed into the control box **77** to cool the metallic members in the interior of control box **77.** The water is collected in a lower collecting box **77*a*'** and is discharged therefrom through outlet pipe **77*b*.**

Turning now to FIG. **5** which is a longitudinal sectional view of control box **71,** the positioning funnel **76** has a flared semi-conical guiding portion **76*a*** and a horizontal semi-cylindrical supporting section **76*b*,** and a downwardly depending leg **76*c*.** The leg **76*c*** has three generally parallel open slots **76*d*, 76*e*** and **76*f*** extending upwardly a predetermined distance from the bottom surface **76*g*.** The positioning funnel **76** is supported on bolts **76*h*.** The positioning funnel **76** can be moved vertically by cam **74*b*** (shown in FIG. **6** and described below) extending through slot **76*e*.**

FIG. **6** is a cross-sectional view of control box **77.** The interior metallic parts include the positioning funnel **76'** and a U-shaped bracket assembly **111** extending upwardly on either side of the downwardly depending leg **76*c*** supported upon and vertically movable by a rotatable shaft **74.** The U-shaped bracket has two parallel upwardly extending legs **112** welded to a horizontal base member **113.** A plurality of support legs **114** extend downwardly from the bracket assembly. A pair of outwardly extending arms **115** perpendicular to the legs **112** aid in aligning the positioning funnel **76'** in the control box **77.** Two nut and bolt assemblies **116** (one is shown) on either side of shaft **74'** extending through the legs **112** and downwardly depending leg **76*c*'**, support the positioning funnel **76'**. The U-shaped bracket assembly gives support to the downwardly depending leg **76*c*'** to prevent distortion of the leg **76*c*'** during use. The positioning funnel **76'** and bracket assembly **111** are vertically movable as a unit. If maintenance is required, positioning funnel **76'** can be lifted out of the control box **77** without removing any other part of the apparatus.

The shaft **74'** extends through the housing **72'** of the control box **77** and is divided into three segments, **74*a*, 74*b*** and **74*c*.** The largest diameter segment **74*a*** provides a bearing surface upon which the shaft can be rotated and gives the strength required to prevent early failure of the shaft. The middle segment **74*b*** is a cam by which the positioning funnel **76'** is positioned. The cam **74*b*** by definition is an eccentric. A circle defined by the outer surface of the cam **74*b*** when it is rotated through 360° has the same diameter as the actual diameter of segment **74*a*.** Therefore, the positioning funnel **76'**, vertically movable on cam **74*b*,** can be raised or lowered a desired distance to position the steel workpiece S axially in the spray unit **50.** Segment **74*c*** has the smallest diameter of the shaft. The segment **74*c*** provides two bearing surfaces **74*d*** and **74*e*** for the shaft **74'** and also aligns the shaft **74'** horizontally and perpendicular to the pass line of the mill.

A pair of metallic support plates **116** and **117,** which extend interiorly the length of the control box **77,** are welded to the end plates **72*a*.** Apertures **116*a*** and **117*a*** of appropriate size are provided in plates **116** and **117,** respectively, to provide bearing surfaces for shaft segments **74*c*** and **74*a*,** respectively.

Metallic mounting brackets **118*a*** extending perpendicularly outwardly from the side plates **72*b*'** of the housing **72'** are provided whereby the control box **77** can be fastened to the end plate **60*b*'** of the spray unit

50 by means such as nut and bolt assemblies (not shown) passed through the apertures **118***a* and mating apertures (not shown) in the end plate **60***b'*.

While we have described the above apparatus as being used to control the temperature of a steel workpiece which is being hot-rolled on a continuous hot-rolling mill, it must be understood that the apparatus can also be used to control the temperature of a steel workpiece which is being prepared by thermomechanical means or by ausforming means or by ferritic rolling means.

We claim:

1. In a continuous hot-rolling mill having a plurality of roll stands for advancing a solid steel workpiece in a predetermined substantially horizontal pass line, the improvement comprising:

a. at least one spray unit comprising a pair of spaced coolant spray chambers, aligned longitudinally in tandem, positioned between two of said roll stands in said mill and surrounding a portion of said pass line,

b. a plurality of spray means in each of said spray chambers for spraying water onto the surface of said steel workpiece as said steel workpiece is advancing along said pass line, and

c. elongated guard means in each of said spray chambers to guard said spray means from contact with said steel workpiece said guard means in each of said spray chambers comprising a plurality of spaced elongated metallic bars generally rectangular in cross section extending longitudinally substantially the length of each of said spray chambers, the space between said guard means providing access for spray water from said spray means to impinge on the surface of said advancing steel workpiece.

2. The spray unit of claim **1** wherein said spray means in each of said spray chambers are arranged in linear rows and the rows of said spray means in one of said spray chambers are rotated a predetermined distance about the pass line of the apparatus from the line of said spray means in said other spray chamber.

3. The spray unit of claim **1** wherein said spray means in each of said spray chambers comprise a plurality of high pressure nozzles in annular configuration; a plurality of said annular configurations being spaced a distance apart longitudinally substantially the length of each of said spray chambers, said high pressure nozzles defining a spray section surrounding a portion of said pass line in said mill.

4. The spray unit of claim **1** wherein a first control means is inserted between said pair of spaced spray chambers to position said advancing steel workpiece in a continuous generally horizontal line when it passes from one spray chamber to the other spray chamber and a second control means is provided at said exit end of said spray unit to guide said advancing steel workpiece in said pass line.

5. The spray unit of claim **1** wherein each of said pair of spray chambers comprises a cover, contiguous with a bottom portion and partially attached to said bottom portion, and said cover being pivotally removable vertically from said bottom portion to expose the interior of said spray chamber.

6. The spray unit of claim **5** wherein the cover of each of said spray chambers is a fabricated elongated box-like header wherein water under a gage pressure of about 25 pounds per square inch to about 60 pounds per square inch can be held prior to spraying onto said surface of said advancing steel workpiece.

7. The spray unit of claim **4** wherein the control means is a control box comprising a metallic cone-like cover provided with a water inlet to prevent said advancing steel workpiece from leaving said pass line of said mill, a semi-cylindrical funnel-like positioning member having a downwardly extending arm provided with a plurality of downwardly open slots, and a pair of pins mounted on said arm wherein two of said slots are supported in a manner so as to restrict horizontal movement of said guide member but to allow vertical movement thereof, the other of said open slots resting on a cam of a shaft extending through said control means and being supported on a bearing member, said shaft being attached to a control arm provided with a central handle whereby said control arm can be rotated to rotate said cam through a distance of 180° when said control arm is raised to a predetermined position to raise or lower said positioning member to position said steel workpiece in said spray chamber.

8. Apparatus for spraying water onto the surface of a steel workpiece advancing along a predetermined substantially horizontal pass line in a continuous hot-rolling mill, to control the temperature of said steel workpiece and produce a product off-the-mill which has an integrated mean temperature of not more than 1,750° F., comprising:

a. a spray unit, having an entry end, a center portion and exit end, positioned to encircle a portion of the pass line, said spray unit comprising:

  1. a pair of spaced spray chambers arranged longitudinally in tandem, each of said spray chambers having a cover contiguous with and partially attached to a bottom portion,

  2. spray means inside of each of said covers and said bottom portions in an annular configuration spaced longitudinally the length of each of the spray chambers,

  3. transverse support means spaced the length of said spray chambers,

  4. guard means fastened to said support means and extending longitudinally the length of said spray chambers,

b. a water collecting and disposal means attached to the bottom of said spray unit, and

c. positioning means at the center section and exit end of said spray unit whereby said steel workpiece is aligned for passage axially through said spray units.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,889,507

DATED June 17, 1975

INVENTOR(S) : Helmut Kranenberg et al.

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Col. 2, Abstract, line 4, "or" should read --of--.

Col. 1 of Background - line 22, "blustery" should read --blistery--

Col. 4, line 32, "shoen" should read --shown--.

Col. 4, line 63, "81" should read --71--.

Col. 6, line 33, "betwen" should read --between--.

Col. 6, line 51, "fabriacted" should read --fabricated--.

Col. 7, line 40, "80a" should read --80a'--.

Col. 7, line 64, "bee" should read --be--.

Col. 8, line 68, "assemply" should read --assembly--.

Col. 9, "a generally" should read --A generally--. (Capital A).

Signed and Sealed this

sixteenth **Day of** *September 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks