April 12, 1966 YOSHIO TAKAISHI 3,245,671

COOLING METHOD AND APPARATUS FOR HOT ROLLED STEEL ROD

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FIG 1

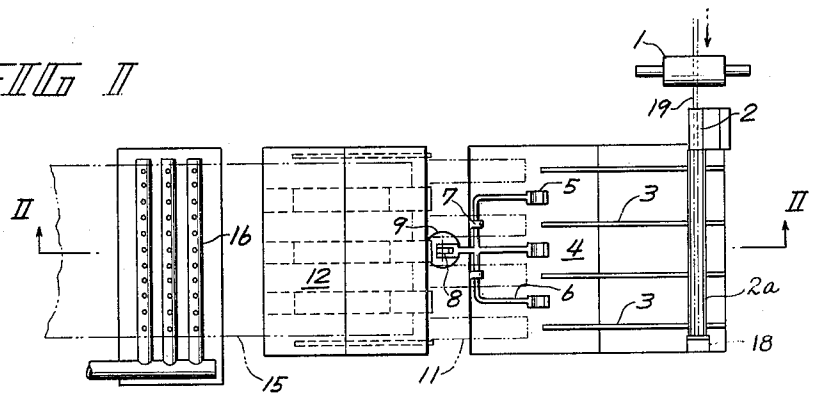


FIG 2

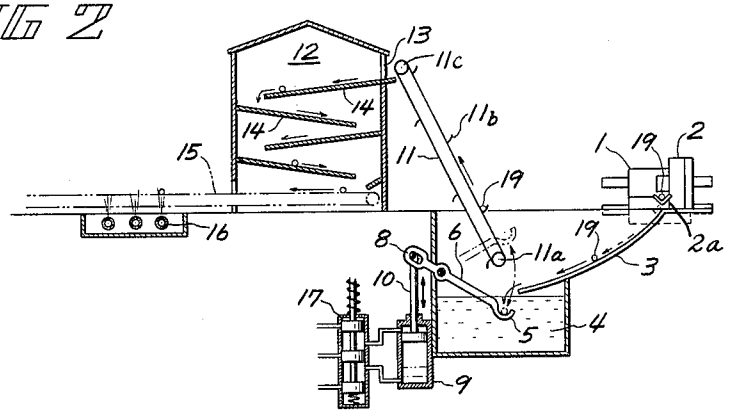
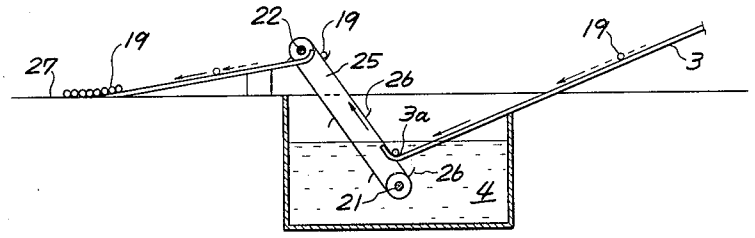


FIG 3



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FIG 4

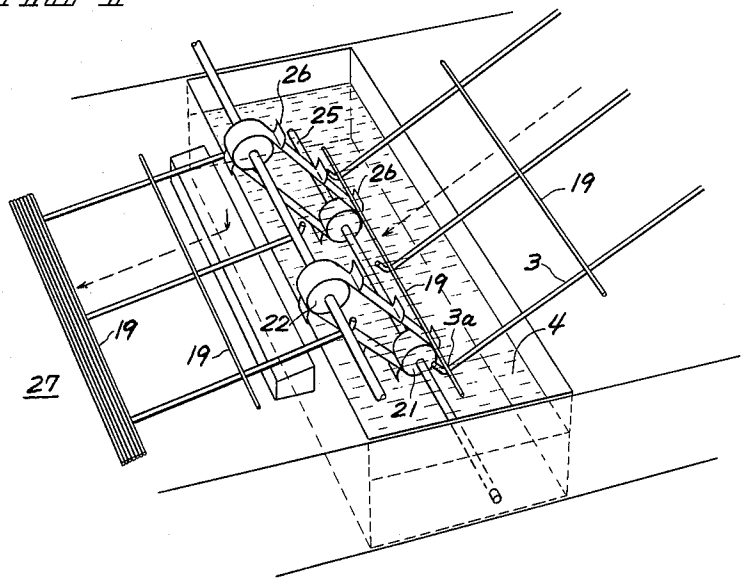
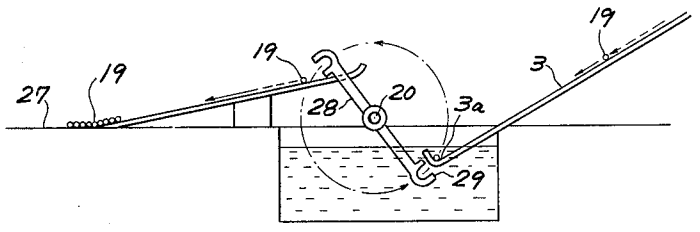


FIG 5



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FIG 6

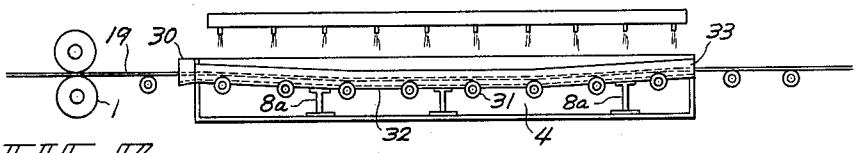


FIG 7

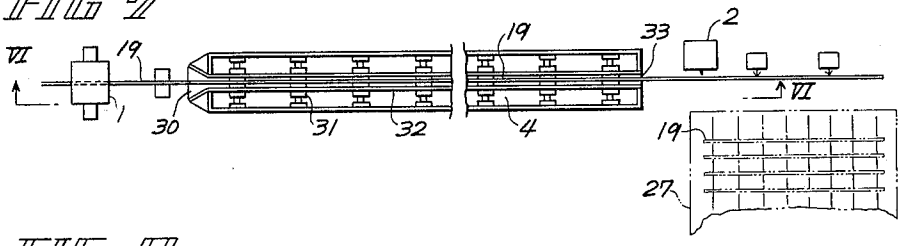


FIG 8

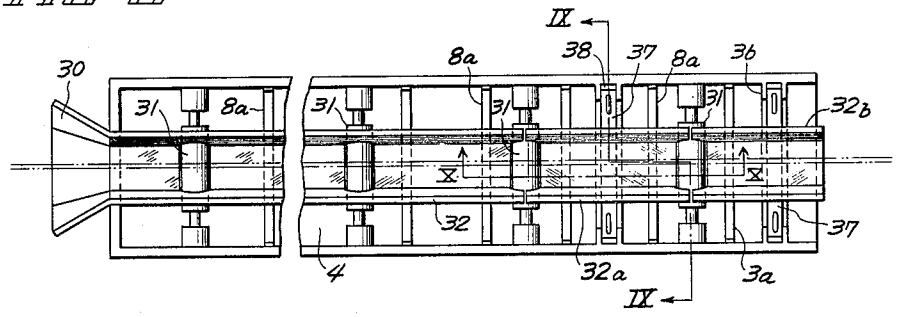


FIG 9

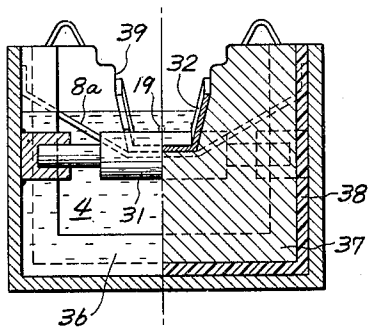
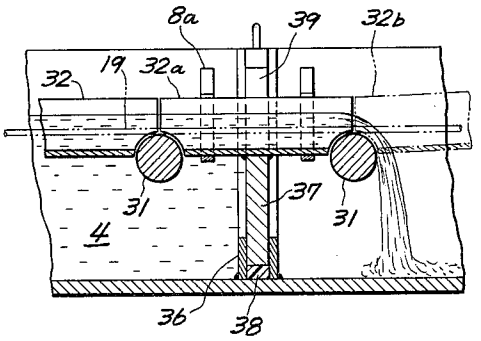


FIG 10



INVENTOR.

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United States Patent Office 3,245,671 Patented Apr. 12, 1966

3,245,671
COOLING METHOD AND APPARATUS FOR HOT ROLLED STEEL ROD

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Filed Apr. 8, 1963, Ser. No. 271,363
10 Claims. (Cl. 266—4)

This invention relates to an improved rapid cooling method and a novel cooling apparatus for hot steel rod delivered from hot finishing rolls, particularly to means for cooling the steel rod which comprises a cooling liquid tank assembly and an equalizing chamber which are installed between the hot finishing rolls and the cooling bed, to control the cooling rate of the hot steel rod, hence the outer portion of the hot steel rod is primarily cooled in the liquid tank and then secondly the temperature of both the inner and outer portions of said steel rod is equalized in said equalizing chamber and then said rod is cooled on the cooling bed in the atmosphere.

In an ordinary way, the hot rolled steel rod, produced heretofore, delivered in a hot state from finishing rolls, is cut off in the desired length by a suitable cutter, then cooled on the cooling bed in the atmosphere. Therefore, it requires a wide area cooling bed and the finished steel rod is mild, of low strength and high elongation.

According to the invention, the hot rolled steel rod delivered from the finishing rolls, initially passes through the cooling liquid in the tank within a few seconds, consequently the outer portion of the steel rod is cooled rapidly and the inner portion of the steel rod is still in hot or high temperature and then this steel rod in this condition is carried to the equalizing means where the temperature difference between the outer portion and the inner portion of the steel rod is balanced or equalized to a certain temperature in several minutes and then successively cooled to the ambient temperature on the cooling bed. By the cooling method of the invention, the steel rod produced is of higher strength and lower elongation and also the area of the cooling bed is narrowed remarkably and the cooling time on the cooling bed is decreased too.

An object of this invention is to provide the process of martempering the outer portion of the steel rod and of austempering the inner portion of the steel rod in order to increase tensile strength and decrease elongation of the rod.

Another object of this invention is to provide a water tank and its assemblies, to control the cooling time or cooling rate of the steel rod, in order to retain the desirable sufficient heat quantity in the outer portion.

Still another object of this invention is to provide equalizing means to equalize the temperature difference between the outer portion and the inner portion of the steel rod, leading the temperature of both portions to the range of about from 300 to 650 degrees C. and then cooling the steel rod to the ambient temperature on a cooling bed.

Other objects and advantages of the invention will be more fully understood from the following description of preferred forms of the invention shown by way of example in the accompanying drawing in which:

FIG. 1 is a schematical plan view of the embodiment in accordance with the invention.

FIG. 2 is a side view with portions shown in vertical section taken on the line II—II in FIG. 1.

FIG. 3 is a schematical side view of another embodiment of this invention.

FIG. 4 is a perspective view of FIG. 3.

FIG. 5 is a schematical side view of still another embodiment of the invention.

FIG. 6 is a vertical sectional view of a modification of the cooling tank taken on the line VI—VI in FIG. 7, and FIG. 7 is a plan view of FIG. 6.

FIG. 8 is a plan view of another embodiment of the cooling tank which is adjustable lengthwise.

FIG. 9 is a vertical sectional view taken on the line IX—IX in FIG. 8.

FIG. 10 is a side view of the outlet portion of the tank taken on the line X—X in FIG. 8.

Referring now to the drawings FIG. 1 and FIG. 2, there are shown a pair of hot finishing rolls **1** for the steel rod **19**, cutting device **2**, turnable V-shaped slide guide **2***a* and chute rails **3** extending transversely and downwardly from beneath the slide guide **2***a* over one side of the cooling water tank **4** and into the center portion of the tank. Adjacent to the lower end of the chute rails **3** there are hooks **5** on one end of a swingable fork **6** which is pivoted to an opposite side of the tank **4** at its middle point **7**. The opposite end of the fork **6** is hinged by pin **8** to the piston rod **10** of the cylinder **9** which is connected by a valve **17** to a suitable power source (not shown) to rotate the fork **6** as explained later.

The lower wheel shaft **11***a* of the hook conveyor **11** is supported rotatably by the side walls of the cooling tank **4**, and the lower hooks of the conveyor **11** are in communication with said forks **6**. The upper wheel shaft **11***c* of the hook conveyor **11** is supported rotatably to the wall of the equalizing chamber **12** and the upper hooks of the conveyor **11** are in communication with the inlet port **13** of the heat equalizing chamber **12**. In the equalizing chamber **12**, the slightly inclined chute rails or conveyer **14** are provided in zig-zag relation to equalize the temperature difference between the outer portion and the inner portion of said rapid cooled steel rod. The lowest end of the inclined chute rails or conveyor **14** is communicated with the horizontal conveyer **15** to transfer the heat equalized steel rod from the equalizing chamber **12** to the ambient air, and the steel rod on the conveyer **15** is cooled by an air jet from compressed air pipe **16** or the natural air almost to the ambient temperature and finally the cooled steel rod is transferred to the storage. Before starting of the process of the invention, the oil burner (not shown) mounted in the equalizing chamber **12** is initially ignited to heat the air of the equalizing chamber **12** to a suitable heat range from 300 to 650 degrees C. in accordance with the size or the quality of the steel rod, and after the air is suitably heated, the ignition of the burner is stopped. Simultaneously the water level and the swinging speed of the fork **6** of the cooling tank assemblies are suitably adjusted. In the operation of the process, the hot rolled steel rod, having the temperature of about 1000 degrees C., is rolled out from the finishing rolls **1** and run through the cutting device **2** along the slide guide **2***a* to its stopper **18** and is cut off in a predetermined length. By overturning the slide guide **2***a* or pushing by suitable means, the hot steel rod is sent transversely down the inclined chute rails **3** into the water of the cooling tank **4**. Immediately the steel rod is taken on the hooks **5** of the swinging fork **6** and cooled in a few seconds in the water and then the fork is swung up with the steel rod by the action of the piston rod **10** and the steel rod is taken out from the water. For the standard size steel rod, the time employed to pass through the water in the cooling tank is a few seconds, as shown hereinafter in the Table No. 1. The outer portion of the steel rod is cooled and the inner portion of the steel rod remains in a hot state. Then the steel rod on the hooks **5** is transferred to the hooks **11***b* on the conveyer **11** and lifted upwardly and supplied to the inlet port **13** of the equalizing chamber **12**. The steel rod moves from the inlet port **13** onto zig-zag chute rails **14** very slowly, and

slides down to the bottom of the equalizing chamber **12** in a predetermined time and the temperature difference between the temperature of the outer portion and the inner portion is equalized and is leveled to the predetermined temperature of the equalizing chamber **12**. The equalized steel rod is transferred to the conveyer **15** from the outlet port on the bottom of the equalizing chamber **12**. The steel rod on the conveyer **15** is carried very slowly and cooled by either the upward air jet **16** or the atmosphere and finally transferred into the storage.

In operation, if the temperature of the equalizing chamber becomes higher than the predetermined temperature, cooling time in water may be prolonged by the increase of the water level or by the decrease of the speed of forks, or the temperature in the chamber may be lowered by blowing ambient air into the equalizing chamber **12**. Conversely, if the temperature of the equalizing chamber **12** is lowered from the predetermined temperature, the cooling water level may be decreased or, the burner may be ignited again in the equalizing chamber to raise the temperature.

Referring now to the embodiment of FIGS. 3 and 4, the equalizing chamber and the swingable lever **6** in FIG. 1 are omitted and the hot rolled steel rod delivered from the slide guide **2***a* is supplied to the hooks **3***a* which is provided at the end of the chute rails **3** in the tank. The steel rod on the hooks **3***a* is moved on the hooks **26** of the endless conveyor **25**, which is extended between the lower guide wheels **21** and the upper guide wheels **22**. The steel rod on the hooks **26** is then carried upwardly from the water level in the cooling tank **4** and transferred from the hooks **26** to the cooling bed **27** on which the temperature of the cooled steel rod is equalized, and then the steel rod is cooled further to the ambient temperature. In the method of this embodiment the cooling time of the hot rolled steel rod in the cooling water may be adjusted by the control of the speed of the revolution of the driving shaft and/or the control of the height of the water level in the cooling tank.

Referring to a FIG. 5, this embodiment is the modification of the embodiment shown in FIG. 3. The steel rod suspended on the shooks **3***a* of the chute rails **3** in the cooling water is taken up on the U-shaped member **29** attached to the end of the arms **28** supported on the rotating shaft **20**, and is carried upwardly from the water level of the tank onto the chute rails by the rotation of the shaft **20** and move down said rails to the cooling bed **27** on which the temperature of the cooled steel rod may be equalized, and then the steel rod is further cooled to the ambient temperature on the cooling bed **27**.

Referring to FIG. 6 and 7, which shows a modification of the tank in FIGS. 1 and 2, the hot rolled steel rod **19** delivered from the finishing roll **1** is supplied directly into the cooling water tank **4** through the inlet port **30**. In the cooling tank **4** there are provided a plurality of suitably spaced conveying rollers **31** and a slightly, downwardly curved guide channel **32** which are held by supports **8***a*. The steel rod passes lengthwise through the cooling water tank at a high speed and exits from the outlet port **33** to the cutting device **2** to be cut off to the desired length and is then conveyed aside the equalizing chamber **12**. In said chamber the temperature of the steel rod is equalized after a short time as explained. When it is desired to adjust the equalized temperature of the steel rod in the equalizing chamber, it is only necessary to adjust the height of the water level in the cooling tank.

Referring to FIGS. 8–10, there is another embodiment of a cooling tank having conveying rollers **31** and the elongated guide channel **32** in which the inlet portion and the intermediate portion o fthe guide channel are similar to that shown in FIGS. 6 and 7, but the outlet portion of the guide channel **32** is divided by the conveying rollers into several guide channel segments **32***a*, **32***b* for adjusting the effective length of the cooling water tank **4** by taking off the channel segments **32***b* to pour the excessive water out, as shown in FIG. **10**. The intermediate portion of the guide channel segments **32***a* is secured to the U-shaped recess **39** of the upper portion of the sealing plate **37**. Said sealing plate **37**, provided with the packing **38** around its edge, can be fitted to or removed from the U-shaped groove **36** on the inner surface of the cooling water tank with equal distances. Said conveying rollers **31** are positioned slightly upward to the bottom of the guide rails **32** and **32***a*, received by the supporting rod **8***a*.

When it is desired to decrease the cooling time for the hot rolled steel rod in the water, any guide channel segment **32***a*, **32***b* with the sealing plate, positioned at the outlet end of the cooling water tank **4**, is removed in turn from the U-shaped groove **36** and then the length of the cooling tank may be shortened.

Conversely, when it is desired to increase the cooling time, one or several guide channel segments **32***a* with the sealing plate **37** may be fitted into the U-shaped groove **36** in turn toward the outlet end of the tank **4**. After the steel rod passes through the cooling tank **4**, which is generally of a length corresponding with the size of the steel rod, the steel rod is transferred to the cutting device **2** and cut off in the desired length and is then conveyed to the equalizing chamber as previously discussed.

The following table clearly illustrates the quality of the steel rod produced by the invention. The contents of the steel rod of this test was: carbon 0.41%, manganese 0.37%, silicon 0.21%, phosphor 0.013% and sulphur 0.020%. The size of the steel rod of this test was 16 mm. in diameter.

Table 1

	Tensile strength, kg./mm.^{2}	Elongation, percent	Bending test
Steel rod cooled in air	63.5	19.3	Good.
Water cooled 2 seconds	73.1	14.5	Better.
Water cooled 3 seconds	88.2	12.4	Do.
Water cooled 4 seconds	104.0	8.1	Do.
Water cooled 5 seconds	115.3	1.1	Broken.

It will thus be seen that the cooling method and apparatus in accordance with the invention provides for the reduction of the cooling time of the hot steel rods, reduction of the area of the cooling bed and increase of the tensile strength of the steel rod.

The present invention has been explained in connection with particular embodiments thereof; however, it is to be appreciated that the invention is not intended to be limited thereby. To the contrary, various structural changes may be made in the various embodiments without departing from the intended spirit and scope of the invention as defined in the appended claims.

Having thus described my invention, I claim:

1. An apparatus for cooling hot rolled steel rods comprising: a quenching tank, said tank being at least partially filled with a cooling fluid for cooling the outer surface of said rods without substantially affecting the temperature of the core thereof, means for conveying said rods to said quenching tank, means for conveying said rods through said tank and adapted to adjust the quenching time in the quenching tank, means operable at a temperature between 300 to 650° C. for equalizing the temperature between the surface and the core of each of the rods, means for conveying said rods from said quenching tank through said equalizing means, means for cooling said surface and core of each of said rods to the ambient temperature and means for conveying said rods from the equalizing means through said cooling means.

2. An apparatus for cooling an extended length of hot rolled steel rod comprising: a device for cutting said extended rod into equal sections, means for conveying said extended rod into said cutting means, a liquid filled quenching tank for cooling the outer surface of each of said rod sections, means for guiding said rod sections, one

at a time, from said cutting means into the quenching tank, means for equalizing the temperature between the surface and the core of each of said rod sections, means for conveying said rod sections through said quenching tank and into said equalizing means, said equalizing means being operable at a temperature between 300° C. to 650° C., means for guiding said rod sections through said equalizing means, means for cooling the surface and core of each of said rod sections to the ambient temperature, means for conveying said rod sections from said equalizing means through the cooling means.

3. An apparatus as recited in claim 2 wherein the means for conveying each of said rod sections through said quenching tank and into said equalizing means consists of: a swingable means journalled over the quenching tank, said swingable means having a hooked end for receiving one rod section at a time guided from the cutting means, actuating means for oscillating said swingable means to dip said rod section into said quenching tanks and then lift the rod section out of said quenching tank, an endless conveyor having a loading end and a discharging end, means for driving said endless conveyor, said loading end of the endless conveyor being adjacent the swingable means, said discharge end of the endless conveyor being adjacent the equalizing means, at least one carrying means mounted on the working face of said endless conveyor for picking up the rod section from said swingable means at the loading end of said conveyor and discharging the rod sections into the equalizing means at the discharging end of the conveyor.

4. An apparatus as recited in claim 2 wherein the equalizing means consists of a heated box like enclosure having an inlet at the upper end of the enclosure and an outlet at the lower end of the enclosure, a guiding means within said box like enclosure for the rods received from the quenching tank consisting of a first series of parallel, spaced inclined guides fixed to a first inner wall of said enclosure in a vertical line, each extending downwardly toward the opposite wall of said enclosure and adjacent thereto, a second series of parallel spaced inclined guides fixed to the opposite wall of said enclosure in a vertical line and extending downwardly toward the first wall and adjacent thereto, said second inclined guides being arranged alternately with said first included guides to form a zig zag path for the rods through the enclosure from the inlet to the outlet thereof.

5. An apparatus as recited in claim 2 wherein said means for conveying said rod sections through said quenching tank and into said equalizing means consists of: an endless conveyor having a loading end and a discharge end, said loading end being positioned in the quenching tank below the quenching liquid level, said discharge end being positioned adjacent the equalizing means for discharging the rod section into the equalizing means, at least one carrying means fixed on said endless conveyor for picking up a rod section from the quenching tank at the loading end of said endless conveyor.

6. An apparatus as recited in claim 2 wherein said means for conveying a rod section through said quenching tank and into said equalizing means consists of: a dipping means journalled over said quenching tank, means for rotating said dipping means, at least one rod carrying means on said dipping means positioned below the surface of the quenching liquid for at least a portion of the rotation of said dipping means, a loading position and a discharge position for each of said rod carrying means, said loading position being arranged below the surface of said quenching liquid for picking up a rod section from the quenching liquid for conveying said rod section to the discharge position where it is discharged into the equalizing means.

7. An apparatus for cooling an extended length of hot rolled steel rod comprising: an elongated quenching tank at least partially filled with a quenching liquid for cooling the outer surface of said extended rod without substantially affecting the temperature of the core thereof, said tank having an inlet at a first end thereof and an outlet at a second end thereof, a device for cutting said extended rod into equal sections, means for continuously conveying said extended rod from the hot rolls through the quenching tanks from the inlet to the outlet thereof and into the path of said cutting device, the extended rod being held beneath the surface of said quenching liquid for at least a portion of its travel through the quenching tank, means for actuating said cutting device to cut said extended rod into equal rod sections, means operable at a temperature between 300–650° C. for equalizing the temperature between the surface and the core of each of said rod sections, means for conveying each of said rod sections from said cutting device through said equalizing means, means for cooling the surface and core of each rod section to the ambient temperature, means for conveying said rod sections from the equalizing means through said cooling means.

8. An apparatus as recited in claim 7 wherein means are provided for adjusting the effective length of the quenching tank.

9. An apparatus as recited in claim 7 wherein there are removable guide rail sections within the quenching tank mounted end to end forming a trough with its sides parallel to the sides of the tank and extending at least partially along the length of the tank from the inlet to the outlet encircling the extended rod being conveyed therethrough, a series of seal mounting means spaced along the sides of said quenching tank, at least one traverse seal for mating with one of the mounting means to change the effective length of the quench tank in conjunction with removal of guide rail sections.

10. An apparatus as recited in claim 9 wherein there is at least one transverse guide roll journalled in said quench tank between the sides thereof and positioned between a pair of the end to end guide rails and extending up therebetween providing a low friction means upon which the rod travels.

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