Sept. 9, 1969 T. J. RUM **3,466,022**

APPARATUS FOR PROCESSING OF STRIP METAL IN A CONTINUOUS MANNER TO REMOVE UNDESIRED CURVATURE

Filed Oct. 14, 1966 2 Sheets-Sheet 1

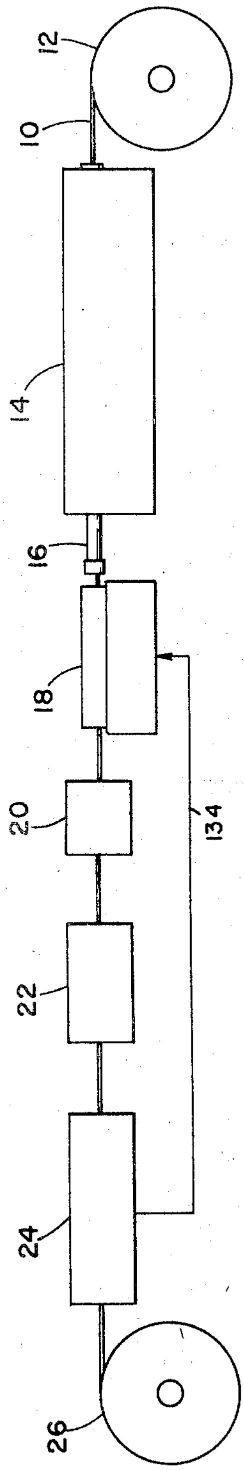

FIG I

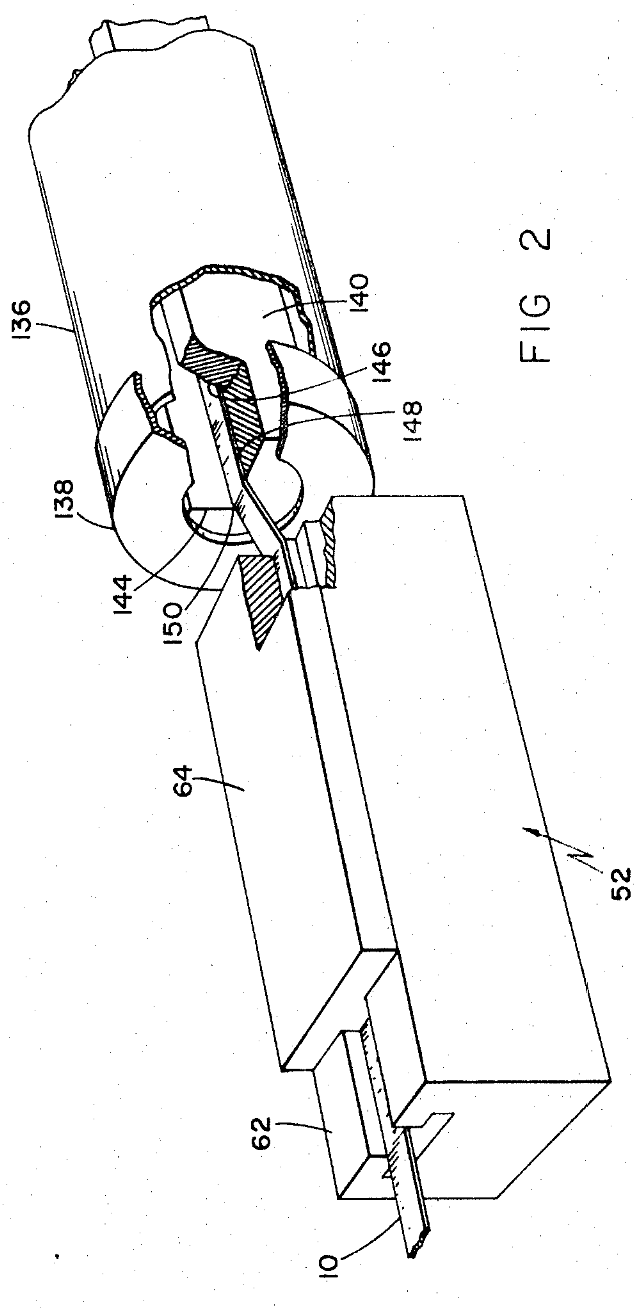

FIG 2

APPARATUS FOR PROCESSING OF STRIP METAL IN A CONTINUOUS MANNER TO REMOVE UNDESIRED CURVATURE

Filed Oct. 14, 1966 2 Sheets-Sheet 2

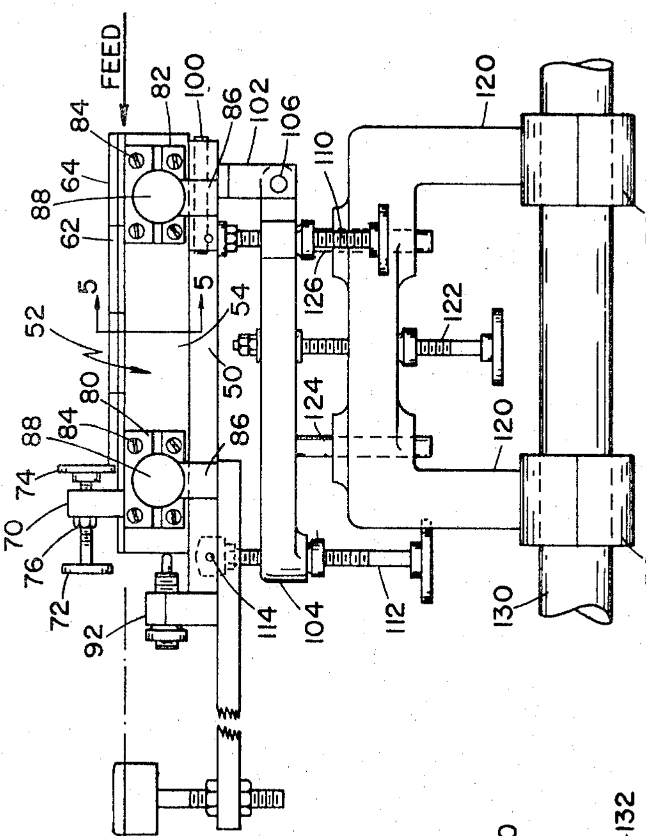

FIG 4

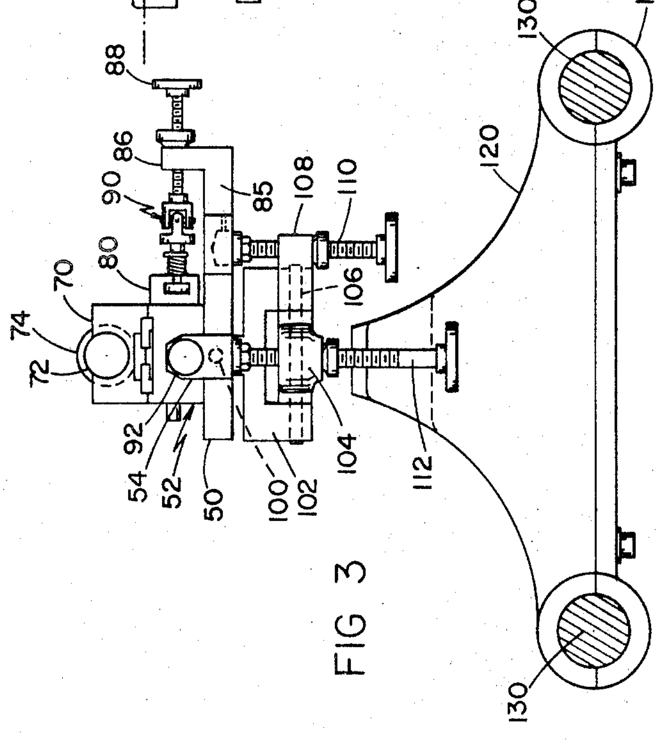

FIG 3

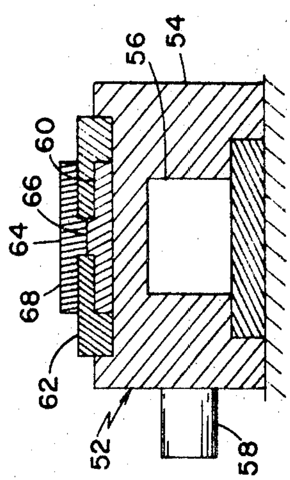

FIG 5

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APPARATUS FOR PROCESSING OF STRIP METAL IN A CONTINUOUS MANNER TO REMOVE UNDESIRED CURVATURE

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U.S. Cl. 266—3 **10 Claims**

ABSTRACT OF THE DISCLOSURE

Razor blade strip steel 0.2 inch wide and 0.0015 inch thick is transferred at a thirty foot per minute rate sequentially through a hardening furnace, an air cooled tubular transition zone, a quench unit, a freeze unit, a tempering furnace, and a continuous inspection station to a take up reel. The vertical position of the quench unit relative to the transition zone is adjustable so that a differential stress may be applied to the steel strip to prevent or minimize a dish condition in the processed strip.

This invention relates to the processing of metal and more particularly to the processing of strip metal in a continuous operation in a manner to remove undesired curvature in the metal strip that extends transversely of its length.

In the processing of strip metal, of the type intended for use in razor blades, for example, a dish condition (curvature in the metal strip transversely of its length) may be produced during the process of the heat treatment of steel. Such a dish condition in the metal strip creates a particular problem related to the process of sharpening the edge of the strip to a shaving edge, as the dish condition effectively offsets the edge of the metal strip to be sharpened relative to the supported body of the strip and the sharpening equipment so that an inferior sharpening process results.

The cause of such a dish condition in stainless steel strip is believed to result from an imbalance in the chemical composition and/or microstructure of the steel strip produced during the rolling process, specifically a difference in the amount of carbon and/or the size and distribution of carbon present at the two surfaces of the steel strip. During the heat treatment process, a difference in the resulting carbon content of the austenite at the opposite surfaces of the strip results in a differential expansion (or contraction) of one surface of the strip relative to the other, and the resulting dish condition.

Accordingly, it is an object of the invention to provide novel and improved methods and apparatus for removing a dish condition from strip metal in a continuous processing operation.

In accordance with the invention, a dish condition is removed from a steel strip by subjecting the surfaces of the strip to a stress differential as austenite is being converted to martensite, the strip having passed through a hardening furnace but prior to the quenching of the strip during the hardening process. In the preferred embodiment of the invention, this stress differential condition is produced by bending the strip over a relatively sharp edge surface when the austenite to martensite conversion is still progressing.

In such continuous process, stainless steel strip, after passage through an austenitizing furnace in which it is subjected to a temperature of about 2000° F. to form austenite has its temperature reduced at a controlled but relatively rapid rate to form martensite. When the temperature of the strip reaches approximately 320° F. (the martensite to austenite transformation still progressing) the strip is subjected to mechanical working if a dish condition is detected to exist. This mechanical working is imposed on the steel strip just prior to entry into a quench device and comprises subjecting the strip to an abrupt change in direction by bending it over a relatively sharp edge. In the preferred embodiment, a transition zone between the furnace and the quench unit is an air cooled tubular element that includes a guide structure of low thermal conductivity which guides both the edges and bottom surface of the strip. In the absence of dish, the horizontal strip support surface of the guide structure is aligned with the corresponding support surface of the quench unit. Where a dish condition is detected, the position of the quench unit relative to the guide surface in the transition zone is changed, preferably by lowering the quench unit, so that the strip is stressed as it passes over the edge of the guide structure at the end of the transition zone and also further stressed as the strip is again deflected through contact with the quench unit.

This processing of strip steel in this manner enables reduction of the dish condition to within a process limit of .0007 inch over a strip width of 0.193 inch and to a corresponding limit for strip of different width. In a process line where a dish sensor is employed, the position of the quench unit relative to the transition zone may be controlled automatically to produce hardened steel razor blade strip that is substantially flat.

Other objects, features and advantages of the invention will be seen as the following description of a particular embodiment thereof progresses, in conjunction with the drawings in which:

FIG. 1 is a block diagram of a steel strip hardening process line as used in the practice of the invention;

FIG. 2 is a diagrammatic perspective view of the transition between the transition zone and the quench unit;

FIG. 3 is an end view of the quench unit and its support arrangement as used in the practice of the invention;

FIG. 4 is a side view of the apparatus shown in FIG. 3; and

FIG. 5 is a sectional view of the quench unit taken along the line 5—5 of FIG. 4.

A processing line for treating stainless steel strip in a hardening and tempering operation to provide a strip of suitable metallurgical characteristics capable of having formed thereon a durable, high quality shaving edge is shown diagrammatically in FIG. 1. That processing line includes a supply reel **12** from which the strip **10** is taken for transfer sequentially through a hardening furnace **14**, an air cooled transition (fourth) zone **16**, a quench unit **18**, a freeze unit **20**, a tempering furnace **22**, and a continuous inspection station **24** to a take-up reel **26**. The strip **10** processed in this line is in the order of 0.2 inch wide and 0.0015 inch thick. The steel employed in the preferred embodiment has the following composition range:

	Percent
Carbon	0.37–0.44
Chromium	13.0–14.0
Manganese	0.20–0.50
Silicon	0.20–0.50
Molybdenum	1.15–1.35

the balance being essentially iron.

In the processing operation, the strip **10** is advanced at a constant rate of about thirty feet per minute and is heated to a temperature of approximately 2000° F. in furnace **14**. At the output of the furnace, the steel is subjected to an air cooled environment so that its temperature is about 320° F. at the end of tubular zone **16**. This fourth zone tube may vary in length, a sixteen inch length being satisfactory in this system such that the austenite to martensite conversion begins in this unit and is still in progress at the exit end of tube **16**. The strip is then further cooled by passage through a water cooled quench block assembly **18** and then a freeze cooling unit **20** which is operated at approximately −90° F. The steel is then passed through tempering furnace **22**, which is maintained at approximately 500° F., and then through inspection station **24** where the quality of the processed steel is inspected. The heat treated steel is then wound on take-up reel **26**.

The vertical position of the quench unit relative to the output of the fourth zone is adjustable as indicated in FIGS. 3 and 4. That assembly includes a table **50** on which a quench block structure **52** is supported. As indicated in FIG. 5, that quench block structure includes a body **54** which defines a passage **56** to which are connected inlet and outlet tubes **58** for the flow of cooling water through the body. Supported on the body is a series of lower quench plates **60** held in place by clamp elements **62**, and a corresponding series of upper quench plates **64**. These quench plates in this particular embodiment are manufactured of carbide (Carboloy grade 907) and each quench plate includes a central ridge **66** which contacts the upper surface of the steel strip **10** (not shown in FIGURE 5) as it moves over the series of lower plates **60**. The ends of the quench plate ridges **66** are radiused in the order of 0.025 inch and provide a smooth transitional surface at the entry of the strip to the quench unit. At the forward end of the quench block base **54** there is mounted an upstanding bracket **70** that receives an adjustment screw **72** and has a stop member **74** secured to its end. A lock nut **76** cooperates with bracket **70** to lock screw **72** in position so that the stop member **74** may hold the series of upper quench plates in the desired position relative to the body **54**.

The quench block unit is coupled to table **50** by side plate elements **80**, **82** which are secured to the sides of the base **54** of the quench block by means of screws **84**. Projecting laterally from the platform **50** are two arms **85**, each having an upstanding bracket **86** which receives an adjustment screw **88** that is coupled respectively to the blocks **80** and **82** through a universal joint structure **90**. By movement of the screws **88**, the lateral position of the quench block assembly on the platform **50** may be adjusted. A stop structure **92** is provided at the read end of platform **50** which limits the backward movement of the quench block assembly.

Platform **50** is secured by pin **100** to an upstanding bracket member **102** which in turn is pivotally secured to intermediate member **104** by transverse pin **106**. Member **104** includes an arm **108** that projects laterally from it which receives an adjusting screw **110**. This adjusting screw, at its upper end, engages platform **50** and when moved pivots that platform **50** about the axis defined by pin **100** in a level adjustment operation. At the rear end of intermediate member **104** is still another adjusting screw **112** the upper end which is secured to the rear end of platform **50** by block **114** so that rotation of screw **112** produces rotation of platform **50** about the axis defined by pin **106**.

Intermediate member **104** is supported on a base structure **120** by adjustment screw **122** and is guided by rods **124**, **126**. Adjumstment screw **122** is received in threaded relation by base **120** and is secured to intermediate member **104** so that rotation of screw **122** produces vertical movement of platform **50** (via intermediate member **104**). (While these adjustments and particularly adjustment screw **122** are indicated as manually operable, obvious appropriate adjustment drives such as servo motors may be utilized which respond to signals supplied over line **134** from inspection unit **24** [FIG. 1].) Base **120** is secured on rails **130** by bracket members **132**.

The transition zone structure **16** includes a cylindrical tube **136** which has disposed in it an insert **140** that has a channel of U-shaped configuration as indicated in FIG. 2 that extends the full length of the tube and which is secured in position by four locking screws located in the sides of the tube. The channel has two side walls **144**, **146** and a base wall **148**. The end of base wall **148** is an abrupt straight line surface. This insert is a material of low thermal conductivity and a satisfactory material is Marinite—an asbestos fiber material having an inorganic binder.

In operation, strip **10** is passed through the processing line at a continuous and uniform rate of speed and is continually sensed for a dish condition by a suitable gauging element, a satisfactory gauging element being disclosed in the co-pending patent application Ser. No. 568,-874, filed Oct. 14, 1966, now Patent No. 3,367,688 and assigned to the same assignee as this application. Upon detection of a dish condition the quench block assembly is lowered relative to the guide surface **146** so that the strip steel **10** is forced over the sharp edge **150** at the output end of insert **140**. The upper surface of the strip steel is similarly subjected to a transition of somewhat lesser magnitude by the first upper quench plate **64**. This stressing of the strip is effective to remove the dish condition and result in a substantially flat steel strip, the edge of which is suitable for sharpening by high volume mass production techniques to a durable, high quality razor edge. In general, in the processing of this thin strip steel for commercially acceptable razor blades it is preferred that the orientation of the dish condition be of concave downward configuration. With such configuration, the steel strip is more uniformly guided by the insert **140** in the transition zone and creation of stains (oxidation) on the finished strip is minimized.

Thus the steel strip during the hardening process, is subjected to mechanical working at a point in the process where the condition of the steel is such that it can be mechanically worked without adverse effect (such as marring) on its surface and yet the steel is in such condition that enables a dish condition to be removed through relatively minor manipulation of the steel prior to completion of the austenite to martensite transformation.

While a particular embodiment of the invention has been shown and described, various modifications thereof will be obvious to those skilled in the art and therefore it is not intended that the invention be limited to the disclosed embodiment or to details thereof and departures may be made therefrom within the spirit and scope of the invention as defined in the claims.

What is claimed is:

1. A continuous strip steel treating system comprising a heating furnace, a quenching unit, an air cooled zone interposed between said furnace and said quenching unit, said air cooled zone having a member providing a support surface for said strip, adjustment mechanism for varying the relative height of said quench unit and said support member to subject said strip to a differential stress at the transition between said zone and said quenching unit for reducing transverse curvature of the strip, an inspection station, and a feedback link connected between said inspection station and said adjustment mechanism for operating said adjustment mechanism in response to detection at said inspection station of excessive transverse curvature of said strip.

2. A continuous strip steel treating system comprising a heating furnace, a quenching unit, an air cooled zone interposed between said furnace and said quenching unit, said air cooled zone having a member providing a support surface for said strip, said support member including a horizontal support surface that extends substantially the entire distance between said furnace and said quenching unit, and adjustment mechanism for varying the relative height of said quench unit and said support member to subject said strip to a differential stress at the transition between said zone and said quenching unit for reducing transverse curvature of the strip.

3. The system as claimed in claim **2** wherein said support member further includes a pair of spaced vertical surfaces that function to guide the edges of said strip during passage through said zone.

4. The system as claimed in claim **2** wherein said support member is made of a material of low thermal conductivity.

5. The system as claimed in claim **1** wherein said adjustment mechanism varies the height of said quenching unit.

6. A continuous strip steel treating system comprising a heating furnace, a quenching unit, an air cooled zone interposed between said furnace and said quenching unit, said quenching unit including a water cooled lower quench plate and a juxtaposed air cooled upper quench plate between which plates said strip is passed for quenching, said air cooled zone having a member providing a support surface for said strip, and adjustment mechanism for varying the relative height of said quench unit and said support member to subject said strip to a differential stress at the transition between said zone and said quenching unit for reducing transverse curvature of the strip.

7. The system as claimed in claim **1** wherein said system is designed for heat treatment of razor blade steel.

8. The system as claimed in claim **7** wherein said razor blade steel is stainless steel strip in the order of 0.0015 to 0.0039 inch in thickness, said furnace is adapted to heat said strip to a temperature in the order of 2000° F., and said zone is of a length such that the temperature of the strip at the exit of said zone is in the order of 320° F.

9. A continuous strip steel treating system comprising

a heating furnace for heating a steel strip to produce austenite, means for feeding steel strip through said furnace along a predetermined path, quenching means for converting austenite in said steel strip to martensite, an edge structure disposed between said furnace and said quenching means and lying transversely to the path of the strip, and adjustment mechanism for varying the position of said edge structure relative to said predetermined path to subject said strip to a differential stress at the transition between said edge structure and said quenching means for reducing transverse curvature of the strip.

10. The system as claimed in claim **9** wherein said edge structure has a relatively sharp edge disposed generally perpendicular to the direction of strip movement along said predetermined path.

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