June 30, 1964 A. F. GRAZIANO 3,139,358

METHOD OF PREVENTING RIBBING AND ROPING

Filed June 14, 1961

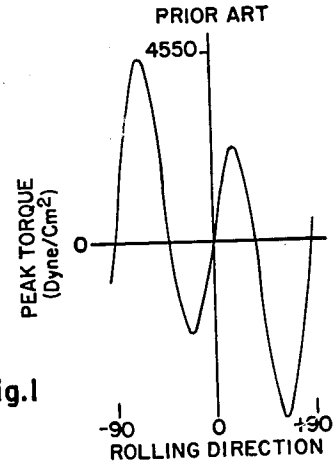


Fig.1

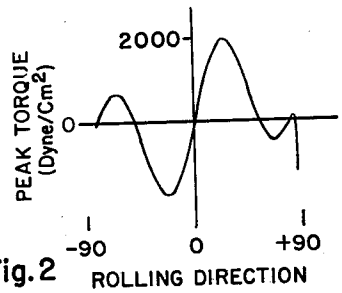


Fig.2

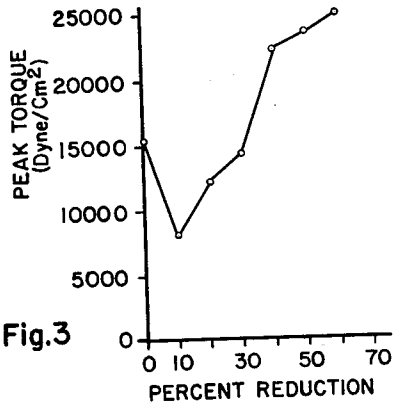


Fig.3

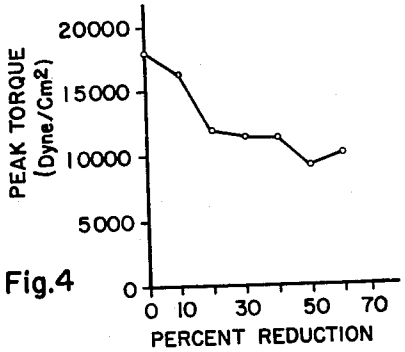


Fig.4

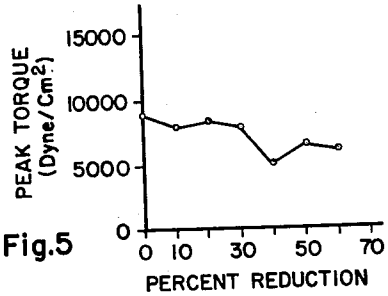


Fig.5

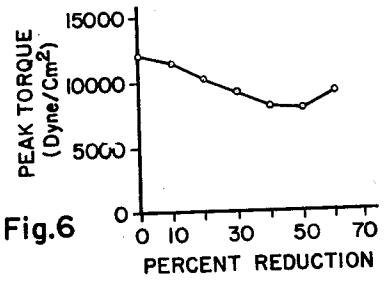


Fig.6

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METHOD OF PREVENTING RIBBING AND ROPING

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This invention relates to methods for producing improved flat rolled ferritic stainless steel, and is particularly directed to a method for producing ferritic stainless steels that are free from the phenomena known as ribbing and roping.

Non-austenitic stainless steels are classified as ferritic stainless steels and martensitic stainless steels. The difference between the two types of high chromium-containing steel analyses is that the balance of their alloying ingredients so affects their structural characteristics that in one type of steel the structure is substantially (though not entirely) ferritic at room temperature and elevated temperatures, and hence does not transform to martensite to any great extent after passing through transformation temperature ranges and is not hardenable to a usable degree. The other analysis effects a phase diagram wherein a heat treatment will bring the steel into the wholly gamma phase; hence, cooling will effect a martensitic or a hardened structure. Stainless steels of the ferritic group generally possess superior corrosion resistance and ductility when compared with the martensitic stainless steels. AISI (American Iron and Steel Institute) Type 430 stainless steel, possessing about 17% chromium, exhibits relatively high resistance to general corrosion, and is particularly recommended for commercial applications were a ductile, workable alloy with good corrosion resistance is required. The properly prepared and polished surface shows good resistance to atmospheric attack and tarnishing. Type 430 is quite ductile, and it is readily formed into desired shapes by pressing, drawing, etc. It is readily formed into various shapes by automatic machines and substantial tonnage goes into moldings and other decorative trim sections. One of its most widely used applications is that of automobile trim.

During plastic deformation, ferritic stainless steels, and particularly Type 430, are susceptible to the formation of alternate, closely spaced ridges and valleys in strained areas. This phenomenon results in an unattractive rippled surface which is detrimental to finished quality of drawn or formed Type 430 stainless steel products. This well-known defect is generally termed "roping." The serious nature of the problem is appreciated when it is recognized that heretofore it has been impossible to remove all evidence of roping from the drawn article by any known polishing or surface treatment technique. "Ribbing" is a term commonly applied to macroscopic ridges which appear on the surface of strip upon cold rolling and which are parallel to the rolling direction. It has been difficult, and often impossible, to produce the requisite surface condition required for certain articles wherein, otherwise, Type 430 would be an ideal material.

Theories presently advanced as an explanation for the "ribbing" and "roping" phenomena are mainly based on the fact that during hot rolling the alloy has a duplex microstructure consisting of ferrite and austenite. Both austenite and ferrite become elongated due to the mechanical deformation in the direction of the rolling. The austenite subsequently transforms to ferrite and carbide to produce a banded inhomogeneous structure. Ribbing and roping are attributed to the differences in mechanical properties of the various banded areas, namely, plastic deformation.

Prior attempts to produce rib- and rope-free ferritic stainless steels include the addition of ferritizers to the composition in an attempt to restrict the "gamma loop" or to adjust the structure of the steel within the normal hot working temperature so that a duplex structure during hot working will not exist. Processing steps and procedures have been rearranged and adjusted in an attempt to modify the banded structure resulting from hot working. Also, recrystallizing heat treatments (above 1800° F.) after hot working and before cold rolling have been taught as a method of reducing ribbing and roping. However, none of the prior known methods has been satisfactory in uniformly eliminating ribbing and roping, particularly roping, where the material is subsequently subjected to mechanical stretching during fabrication. In every instance, only a portion of the finished steel will pass rib and rope tests required by most manufacturers.

It has now been found that by modifying the method of manufacture of ferritic stainless steel strip (particularly AISI Type 430) in the manner of the present invention, strip may be produced that is more uniformly free of ridging and roping than that processed by any of the prior known processing procedures.

In general, the present invention is the discovery that where unidirectionally rolled ferritic stainless steel sheet or strip is subjected to a cold mechanical deformation immediately after hot rolling and then is heat treated at temperatures of from about 1750° F. to 2000° F. before being processed to the desired gauge and finish, the product will be substantially rib- and rope-free. The process of the present invention is applicable to any of the non-hardenable ferritic stainless steels which consist essentially of about 12% to 22% by weight chromium, about .12% max. carbon and the balance iron plus incidental impurities and is particularly useful in producing rib- and rope-free AISI Type 430 stainless steel. To obtain the full benefits of applicant's invention, the hot rolled band is subjected to at least a 40% cold rolling reduction prior to the 1750° F. to 2000° F. heat treatment.

It is therefore an object of the present invention to provide a process for the fabrication of ferritic stainless steels from slabs to unidirectionally rolled sheet or strip products that will be substantially free of ribbing and roping.

It is also an object of the present invention to provide a method whereby stainless steel strip possessing an analysis that consists essentially of from about 12% to 22% chromium, .12% max. carbon and the balance iron plus incidental impurities may be produced that will not exhibit prohibitive ribbing or roping.

It is a further object of the present invention to provide a method of processing AISI Type 430 stainless steel strip so that it will be less susceptible to ribbing and roping.

Other objects and advantageous features of the method of the present invention will be obvious from the following description and the drawings wherein:

FIGURE 1 is a torque magnetometer graph showing actual torque measurements of AISI Type 430 cold rolled strip processed in accordance with conventional practice;

FIG. 2 is a torque magnetometer graph showing actual torque measurements of AISI Type 430 cold rolled strip processed in accordance with the method of the present invention;

FIG. 3 is a graph showing plots and accompanying curve of the peak values of torque magnetometer tests on hot rolled plus various cold rolled AISI Type 430 stainless steel strip samples;

FIG. 4 is a graph such as FIG. 3, wherein the hot and cold rolled strip has been annealed;

FIG. 5 is a graph such as FIG. 3 wherein the hot and

cold rolled strip has been high temperature normalized, and

FIG. 6 is a graph such as FIG. 3 wherein the hot and cold rolled strip has been high temperature normalized and annealed.

Ferritic stainless steels, such as AISI Type 430, undergo at least a partial phase transformation to austenite at hot working temperatures (1600° F.–1750° F.). During unilateral hot working the ferrite and austenite elongate into bands. Upon cooling, the austenite bands decompose into ferrite and carbide or transform into martensite which decomposes into ferrite and carbide upon subsequent heating. Hence, upon microexamination of the hot rolled material, one may observe the banded structure consisting of elongated ferritic grains and elongated ferritic grains plus numerous carbides and/or martensitic areas transformed from the austenite. This banded structure, and particularly the transformed ferrite plus carbide bands, has long been associated with the problems of ribbing and roping. In conventional mill processing, the hot rolled band is usually box annealed at approximately 1500° F. in order to soften the material for subsequent cold rolling by transforming any martensite present into ferrite and to produce a homogenous structure which improves corrosion resistance. Frequently a continuous heat treatment, commonly referred to as a normalize, is employed after hot rolling and before box annealing in an effort to effect recrystallization to eliminate the banded structure. This treatment may vary in temperature from about 1600° F. to 2200° F., and, as stated above, is beneficial in reducing the tendency of the final strip product to exhibit ribbing or to rope upon subsequent fabrication, but has not been found to be a satisfactory answer to the elimination of this problem. The strip is then cold-roll-anneal-cycled to finish gauge so that the over-all present-day commercial practice is as follows:

(1) Slabs of steel (any size, usually between 2" and 12" thick) are heated to about 2250° F. (2000° F.–2400° F.) and are hot rolled to a thickness of about .100" to .250" (the finishing temperature may be as low as 1600° F. and hot rolling may be conducted in several stages).

(2) Normalize (optional) continuously through a furnace at a temperature ranging anywhere from 1600° F. to 2200° F. (usually at about 1700° F. at a rate of 3 minutes in the heat zone per inch of thickness of the strip).

(3) Box anneal (in a protective atmosphere) usually several hours at about 1500° F., but may range as high as 2200° F. for shorter or longer periods of time.

(4) Cold roll (after pickling and/or wheelabrating) to effect a reduction of gauge of from about 25% to 60%.

(5) Anneal (usually a continuous anneal at temperatures of about 1450° F. to 1550° F. followed by a scale-removing pickle).

(6) Cold roll to gauge.

(7) Anneal as in step (5).

(8) Skin pass (optional).

I have found that a torque magnetometer test can be used to quantitatively predict the susceptibility of ferritic stainless steels to ribbing and roping. The peaks of the torque versus the angle of rotation curve increase as does the degree of susceptibility of the steel to ribbing and roping. The torque measurements are interpreted as measurements of crystallographic orientation, and consequently the differences in mechanical properties (plastic deformation) of the bands of ferritic steels believed to be responsible for ribbing and roping are attributed in some measure to crystallographic orientation of the banded or elongated structure. A torque magnetometer curve established for Type 430 stainless steel strip which more nearly approximates a straight horizontal line indicates a steel with substantial random crystallographic orientation, while a curve which has high peaks and valleys indicates a steel with a high degree of orientation. In ferritic stainless steel strip, such as Type 430, crystallographic

orientation is believed to differ between the dual structure bands of the banded matrix. Either the elongated grains of the transformed austenite or the elongated grains of the non-transformed ferrite may be more uniformly crystallographically oriented or both may be equally uniformly oriented but such orientations may differ. In any event, the differences in crystallographic orientation between the bands are thought to effect slippage of the crystals along different planes during mechanical deformation of the metal so as to cause a difference in the mechanical properties between such structures. A measure of the magnetic anisotropy of such strip will indicate its total crystallographic orientation and the magnetic effects of such orientation; however, since such orientation is either largely concentrated in one of the banded structures or the orientation of one of the structures is more responsible for the total magnetic properties than the orientation of the other structure, an indication of high magnetic anistropy will show a high or wide difference in orientation between the banded structures and, consequently, a high or wide difference in mechanical properties between the bands of the banded structure and a tendency to rib and rope. A lower total magnetic anisotropy will indicate lower total crystallographic directionality and, consequently, a lower or narrower difference in orientation between the bands of the banded structure and, consequently, less difference in mechanical properties between the adjacent bands of the dual banded structure and a reduced tendency of the strip to rib and rope.

FIGS. 1 and 2 are torque magnetometer curves showing torque values as measured in dynes per square centimeter. FIG. 1 is a measurement taken on cold rolled AISI Type 430 stainless steel strip processed from a slab in accordance with preferred conventional procedures as shown above. This material exhibited considerable ribbing, and roped severely. FIG. 2 is a similar measurement taken on cold rolled ferritic stainless steel processed in accordance with the method of the present invention as set forth herebelow. It is to be noted that nearly all cold rolled steels exhibit some grain orientation, and this is exhibited by both the material of FIG. 1 and FIG. 2; however, it is readily observable that the peak values of the material of FIG. 1 are much higher than that of FIG. 2, and that the angle of the curve is much more severe. Hence, it is readily seen that the strip processed in accordance with conventional procedures exhibited a higher degree of orientation than material processed in accordance with the present method.

Based on the concept of grain orientation being responsible in some measure for ribbing and roping, it is apparent that the quality of the steel is enhanced by a high temperature treatment following hot rolling because recrystallization effects a more random orientation of the grains. Recrystallization, however, does not readily occur on annealed and soft steel of this analysis and the hot worked material varies as to its structural state. Such variations in the structural state of the hot rolled band may be responsible for the wide variation in results obtained in the finished steel. It is applicant's conception to cold roll the hot rolled band prior to the recrystallization heat treatment. The cold rolled product recrystallizes more readily and completely than the hot rolled band, and consequently reduces the crystallographic orientation and the tendency of the finished strip to rib or rope. Also, in this manner the first cold roll is effected prior to the high temperature normalize or anneal, and after such heat treatment only one cold reduction is required to take the strip to gauge (although, in some instance, it may be desirable to effect two final cold rolling cycles).

FIGS. 3, 4, 5 and 6 show the effects of cold rolling AISI Type 430 hot rolled band on crystallographic

orientation. In these graphs the peak torque values of magnetometer tests, such as are plotted in FIGS. 1 and 2, are plotted against increments of percent reduction in cold roll passes. In FIG. 3, the hot roll band was cold rolled in 10, 20, 30, 40, 50 and 60% drafts (in the same direction as hot rolling) and the peak torque values are plotted against the percent of cold reduction. It may be readily observed that the average orientation of this material dropped at 10% reduction, but climbed steadily at every succeeding increment of cold working. The graph of FIG. 4 shows test results of the hot rolled and cold rolled band of the graph of FIG. 3, after being annealed at 1525° F. (held at temperature for about ½ hour and furnace cooled). Peak torques are higher in the hot rolled and annealed condition and the hot rolled and 10% cold rolled condition than the values shown in FIG. 3, but the magnetic anisotropy decreases, particularly for the material cold rolled in drafts of 40% reduction and more. The material treated as tested in FIG. 4 would be expected to exhibit less ribbing and roping than conventionally processed Type 430. In the graph of FIG. 5, the hot rolled and cold rolled strip (processed as for FIG. 3) was continuously normalized at 1900° F. at a furnace rate of 30 minutes per inch of thickness and air cooled. It is seen that the peak torque values, and consequently the degree of orientation, has been reduced, particularly at 40% reductions and greater. FIG. 6 shows test results obtained from material that was hot rolled, cold rolled, normalized (as in FIG. 5) and annealed (as in FIG. 4). The peak torques are slightly higher than those shown in the graph of FIG. 5, but show a significant improvement in the final cold rolled product. An anneal such as provided to the strip tested for FIG. 6 may be desirable to obtain a homogenous structure and enhance the ultimate corrosion resistance. Applicant's general procedure, therefore, is as follows:

(1) Ferritic stainless steel such as AISI Type 430 stainless steel (any size of slabs, usually between 2" and 12" thick) are heated to about 2250° F. (2000° F–2400° F.) and are hot rolled to a thickness of about .100" to .250" (the finishing temperature may be as low as 1600° F. and hot rolling may be conducted in several stages).

(2) Cold roll the hot rolled band, preferably a draft that will effect at least a 40% reduction in gauge (the hot rolled band must, of course, be descaled prior to cold rolling).

(3) Recrystallize heat treatment. This is preferably a continuous anneal at temperatures of from about 1750° F. to 2200° F., but optionally may be a box anneal within the same temperature range.

(4) Box anneal (optional) several hours within the temperature range of from about 1450° F. to 1700° F.

(5) Cold roll to final gauge (.018" to .035"). This may be done in two stages in which event an anneal between the stages is preferred (usually a 1450° F.–1550° F. continuous anneal).

(6) Skin pass (optional).

The stainless steels to which the present process is beneficial are any of the ferritic stainless steel grades which exhibit or have a tendency to exhibit ribbing when cold rolled and/or roping when subjected to cold mechanical stretching. Such steels contain relatively low carbon contents (about .12% max.), but contain chromium within a broad range (12% to 22%). Although the balance of the composition is essentially iron, such steels may contain, in addition to impurities, incidental additions designed to effect improved specific mechanical and/or corrosion resistance properties. Such steels conventionally contain about .04% max. phosphorus and sulfur as impurities. Up to 1.5% nickel may also be present, either as an intentional addition or an impurity. Silicon and manganese are nearly always present in amounts up to about 1.5% each. These elements are commonly picked up from raw materials during melting or may be purposely added as deoxidizers or desulfurizers. Ferritizers such as titanium, columbium, tantalum, zirconium, vanadium, etc., may be added in amounts up to 2% each, since these additions tend to stabilize the ferritic structure of the steel within the hot working ranges and consequently lessen the tendency of the material to rib and rope. Molybdenum and copper may be added in amounts up to about 1.25% each to enhance the corrosion resistance of the steel. It is, of course, understood that the process of the present invention is applicable to any of the ferritic stainless steels that are susceptible to ribbing and roping, regardless of the exact analyses involved.

The term "cold rolling," as used in the present specification and particularly as applied to step (2) of applicant's processing procedure set forth above, is intended to convey its usual meaning in the trade. Such term generally implies that the strip has been continuously projected between two rolls while applying pressure between the rolls so as to mechanically reduce the gauge of the strip as it passes through. A single "cold roll" is considered to be the total percent reduction in gauge between stress-relieving anneals, and is not regarded as being a single "pass" through the cold rolling mill. In other words, a cold roll effecting a 40% reduction in gauge may involve several passes through a cold rolling mill such as a "Lewis" mill, but is regarded as a single cold roll since there has been no intermediate heat treatment. The term cold rolling also implies that the mechanical reduction is taking place at substantially room temperature. However, it is understood that the effects of cold rolling are not, insofar as the present process is concerned, confined to an exact temperature, but include rolling at temperatures of up to about 500° F.

The following specific examples are given to illustrate the method of the present invention and in no way limit the claims to the exact embodiments set forth.

Slabs of stainless steel having the approximate analyses set forth in Table I below were hot rolled from the temperatures indicated in Table II below to the hot rolled gauges specified. All of the hot rolled bands were pickled free of scale and cold rolled so as to effect approximately a 40% reduction in gauge except for Heats 346553 and 346658, which were experimental heats from which the data of FIGS. 1 through 6 were secured. One slab from Heat 346553 was processed to gauge in a conventional manner which consisted of a normalize of the hot rolled band (1700° F. continuous anneal), a box anneal (1550° F. for six hours) and a cold roll-anneal cycle (1550° F. continuous anneal) to gauge (about .024"). Another slab from this heat (346553) was processed in accordance with applicant's invention (40% reduction of hot rolled band), as set forth in Table II. The conventionally processed material exhibited severe ribbing and roped badly when subjected to stretching and the torque magnetometer properties of this steel are shown by FIG. 1. Another slab from this heat processed in accordance with the present invention exhibited very little ribbing and roping, and the magnetometer properties of this material are shown by FIG. 2. The hot rolled band from Heat 346658 was subjected to the cold rolling drafts and magnetometer tests, the results of which are shown by FIGS. 3–6. All of the rest of the heats showed satisfactory ribbing and roping properties.

Table I

Heat	C	Mn	Si	Cr	Ni	Cb	Ta
346989	.045	.45	.50	16.37	.22	------	------
337634	.048	.51	.46	16.50	.32	------	------
337631	.053	.51	.50	16.35	.21	------	------
337632	.050	.46	.38	16.50	.19	------	------
346975	.054	.49	.59	16.55	.32	------	------
346553	.060	.39	.60	16.14	.28	.22	.02
346658	.056	.43	.37	16.29	.17	------	------

Table II

Heat No.	(1) Slab Size, inches	(2) Hot Roll, [1] ° F.	(3) Hot Roll Width and Gauge	(4) Cold Roll to (gauge), inches	(5) Normalize, [2] ° F.	(6) Cold Roll to gauge, inches	(7) Final Anneal, [3] ° F.
346989	6½ x 38	2,250	38" x .138"	.070	2,000	.031	1,550
337634	6½ x 38	2,250	38" x .194"	.070	do	.031	do
337631	6 x 41¾	2,250	41" x .205"	.065	do	.029	do
337632	6 x 42	2,250	42" x .183"	.065	do	.029	do
346975	6½ x 38	2,250	38" x .180"	.050	do	.020	do
346553 [4]	5 x 50	about 2,300	.155' gauge	about .093	about 1,700	.024	do
346658 [4]	6 x 22	about 2,300	.163" gauge	about .089	about 1,700	.024	do

[1] Hot rolling temperatures are initial slab temperatures, finishing temperatures varied from about 1450 ° F. to 1550 ° F.

[2] Continuous annealing furnace temperature was 2000 ° F. speed of strip line was about 30 minutes per inch of gauge.

[3] Continuous annelaing furnace temperature was 1550 ° F. speed of strip line was about 60 minutes per inch of gauge.

[4] These heats were experimental heats and all values are approximate.

I claim:

1. The process of producing rib- and rope-free ferritic stainless steel strip having a composition which includes from about 12% to about 22% chromium, up to about .12% maximum carbon, and the balance substantially iron with incidental impurities, which comprises, hot rolling slabs of said steel having a thickness within the range between 2 inches and 12 inches and a temperature within the range between about 2400° F. and about 1600° F. to a hot rolled band having a thickness within the range between about 0.10 inch and about 0.25 inch, cold rolling the hot rolled band to effect at least a 40% reduction in the cross sectional area thereof, heat treating the hot and cold rolled band at a temperature within the range of from about 1750° F. to about 2000° F. to recrystallize the steel, and cold rolling said steel to finish gauge.

2. The process of producing rib- and rope-free ferritic stainless steel strip having a composition which includes from about 12% to about 22% chromium, up to about .12% maximum carbon, and the balance substantially iron with incidental impurities, which comprises hot rolling slabs of said steel having a thickness within the range between 2 inches and 12 inches and a temperature within the range between about 2400° F. and about 1600° F. to a hot rolled band having a thickness within the range between about 0.10 inch and about 0.25 inch, cold rolling the hot rolled band to effect at least a 40% reduction in the cross sectional area thereof, heat treating the hot and cold rolled band at a temperature within the range of from about 1750° F. to about 2000° F. to recrystallize the steel, and cold roll-anneal cycle said steel to finish gauge.

3. The process of producing rib- and rope-free ferritic stainless steel strip having a composition which includes from about 12% to about 22% chromium, up to about .12% maximum carbon, and the balance substantially iron with incidental impurities, which comprises hot rolling slabs of said steel having a thickness within the range between 2 inches and 12 inches and a temperature within the range between about 2400° F. and about 1600° F. to a hot rolled band having a thickness within the range between about 0.10 inch and about 0.25 inch, cold rolling the hot rolled band to effect at least a 40% reduction in the cross sectional area thereof, continuously normalizing said hot and cold rolled band at a temperature within the range of from about 1750° F. to about 2000° F. to recrystallize the steel, and cold rolling said steel to finish gauge.

4. The process of producing rib- and rope-free ferritic stainless steel strip having a composition which includes from about 12% to about 22% chromium, up to about .12% maximum carbon, and the balance substantially iron with incidental impurities, which comprises hot rolling slabs of said steel having a thickness within the range between 2 inches and 12 inches and a temperature within the range between about 2400° F. and about 1600° F. to a hot rolled band having a thickness within the range between about 0.10 inch and about 0.25 inch, cold rolling the hot rolled band to effect at least a 40% reduction in the cross sectional area thereof, continuously normalizing said hot and cold rolled band at a temperature within the range of from about 1750° F. to about 2000° F. to recrystallize the steel, and cold roll-anneal cycle said steel to finish gauge.

5. The process of producing rib- and rope-free ferritic stainless steel strip having a composition which includes from about 12% to about 22% chromium, up to about .12% maximum carbon, and the balance substantially iron with incidental impurities, which comprises hot rolling slabs of said steel having a thickness within the range between 2 inches and 12 inches and a temperature within the range between about 2400° F. and about 1600° F. to a hot rolled band having a thickness within the range between about 0.10 inch and about 0.25 inch, cold rolling the hot rolled band to effect at least a 40% reduction in the cross sectional area thereof, continuously normalizing said hot and cold rolled band at a temperature within the range of from about 1750° F. to about 2000° F. to recrystallize the steel, box annealing the normalized steel at a temperature within the range between about 1450° F. and about 1700° F., and cold rolling said steel to finish gauge.

6. The process of producing rib- and rope-free ferritic stainles steel strip having a composition which includes from about 12% to about 22% chromium, up to about .12% maximum carbon, and the balance substantially iron with incidental impurities, which comprises hot rolling slabs of said steel having a thickness within the range between 2 inches and 12 inches and a temperature within the range between about 2400° F. and about 1600° F. to a hot rolled band having a thickness within the range between about 0.10 inch and about 0.25 inch, cold rolling the hot rolled band to effect at least a 40% reduction in the cross sectional area thereof, continuously normalizing said hot and cold rolled band at a temperature within the range of from about 1750° F. to about 2000° F. to recrystallize the steel, box annealing the normalized steel at a temperature within the range between about 1450° F. and about 1700° F., and cold roll-anneal cycle said steel to finish gauge.

7. The process of producing rib- and rope-free ferritic stainless steel strip having a composition which includes from about 12% to about 22% chromium, up to about .12% maximum carbon, and the balance substantially iron with incidental impurities, which comprises hot rolling slabs of said steel having a thickness within the range between 2 inches and 12 inches and a temperature within the range between about 2400° F. and about 1600° F. to a hot rolled band having a thickness

within the range between about 0.10 inch and about 0.25 inch, cold rolling the hot rolled band to effect at least a 40% reduction in the cross sectional area thereof, continuously normalizing said hot and cold rolled band at a temperature within the range from about 1750° F. to about 2000° F. to recrystallize the steel, box annealing said normalized steel at a temperature within the range between about 1750° F. and about 2000° F. box annealing said steel at a temperature within the range between about 1450° F. and 1700° F., and cold rolling said steel to finish gauge.

8. The process of producing rib- and rope-free ferritic stainless steel strip having a composition which includes from about 12% to about 22% chromium, up to about .12% maximum carbon, and the balance substantially iron with incidental impurities, which comprises hot rolling slabs of said steel having a thickness within the range between 2 inches and 12 inches and a temperature within the range between about 2400° F. and about 1600° F. to a hot rolled band having a thickness within

the range between about 0.10 inch and about 0.25 inch, cold rolling the hot rolled band to effect at least a 40% reduction in the cross sectional area thereof, continuously normalizing said hot and cold rolled band at a temperature within the range from about 1750° F. to about 2000° F. to recrystallize the steel, box annealing said normalized steel at a temperature within the range between about 1750° F. and about 2000° F., box annealing said steel at a temperature within the range between about 1450° F. and 1700° F., and cold roll-anneal cycle said steel to finish gauge.

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