

Oct. 13, 1936.

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2,057,518

APPARATUS FOR BRIGHT ANNEALING METALLIC PRODUCTS

Filed Aug. 21, 1934

3 Sheets-Sheet 1

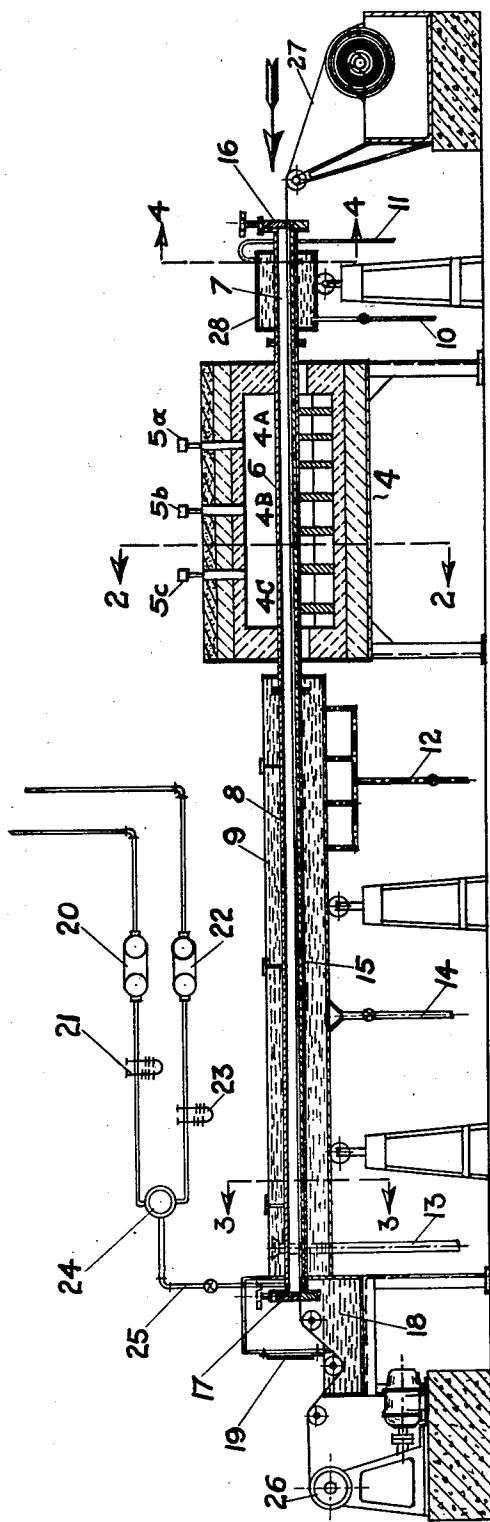


Fig. 1.

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3 Sheets-Sheet 2

Fig. 2.

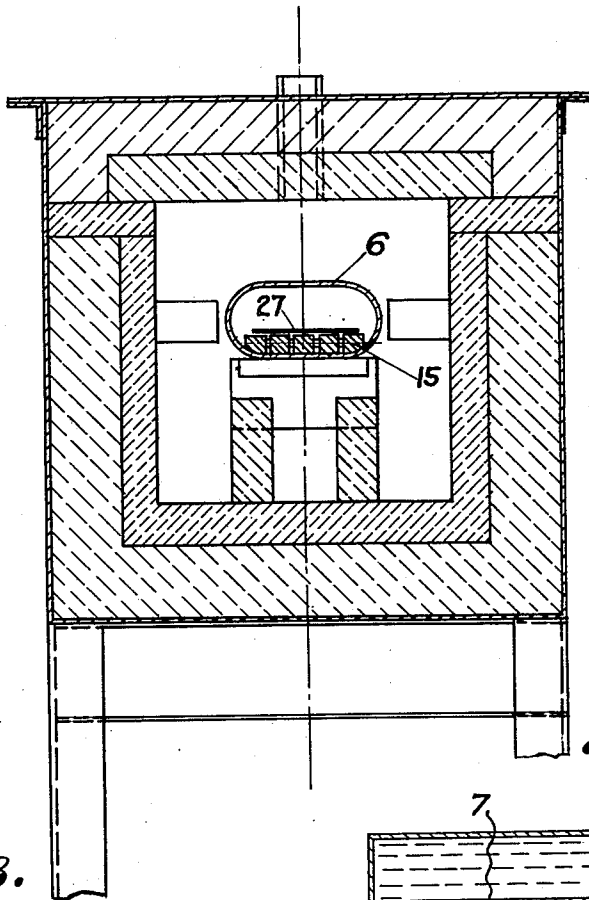


Fig. 3.

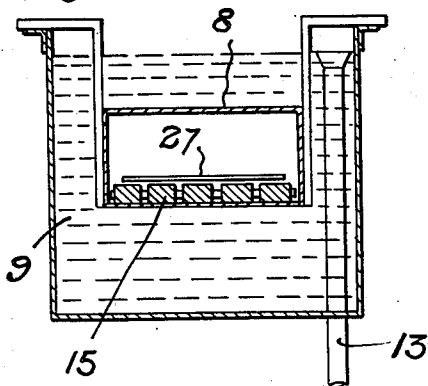
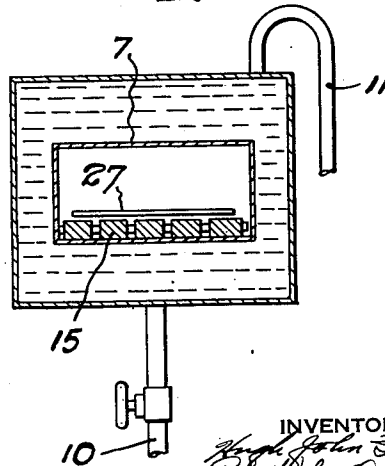


Fig. 4.



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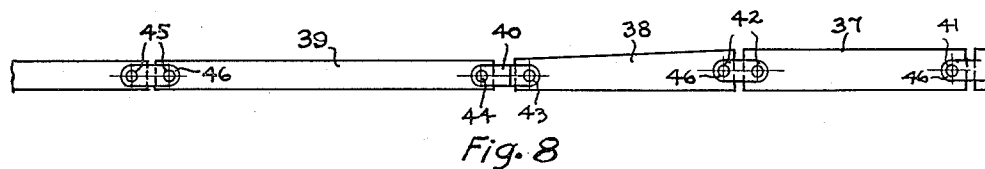
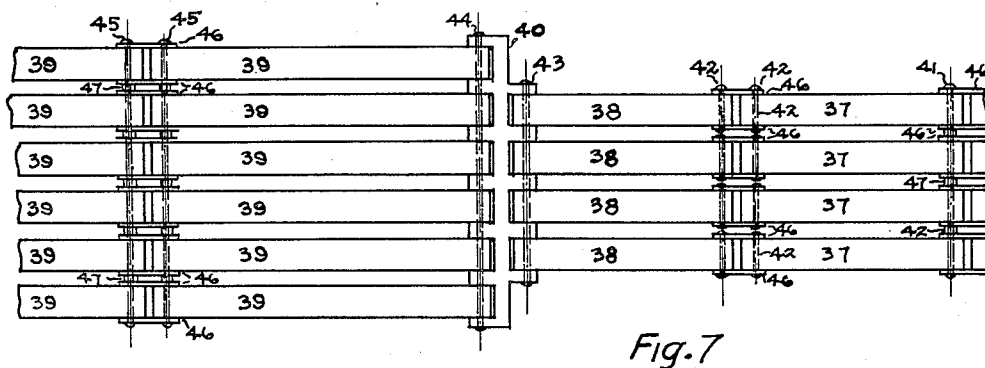
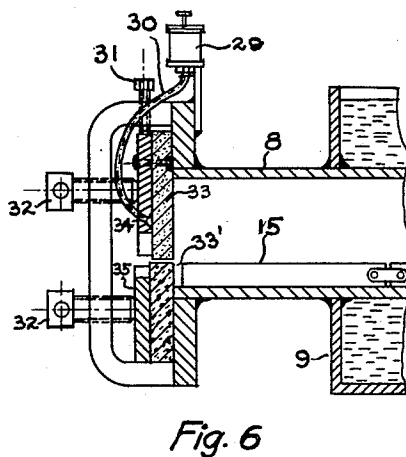
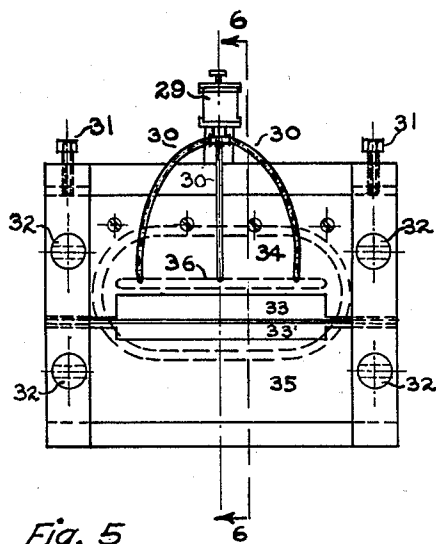
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APPARATUS FOR BRIGHT ANNEALING METALLIC PRODUCTS

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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,057,518

APPARATUS FOR BRIGHT ANNEALING
METALLIC PRODUCTS

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Application August 21, 1934, Serial No. 740,740

9 Claims. (Cl. 266—3)

The present invention relates to an apparatus for bright annealing metallic products and more particularly to a continuous strip apparatus for bright annealing nickel-chromium alloys, nickel-chromium-iron alloys, and other chromium and/or nickel containing alloys therefor.

It is well known that the difficulties involved in the bright annealing of metallic alloys containing chromium were many, especially when the annealing was attempted in a continuous process. The difficulties were due to the high activity of the chromium which at the annealing temperatures reacted with the water vapor, oxygen, or other oxidizing impurities, even when present in small quantities, and formed an oxidic layer containing green chromic oxide over the surface of the alloy. For instance, in attempting to anneal stainless steel of the 18% chromium—8% nickel type in hydrogen, an oxide film containing green chromic oxide was always formed, unless the last traces of the oxidizing impurities were removed from the hydrogen, and the hydrogen entered the annealing chamber entirely free from oxygen and moisture. These were, however, ideal conditions which could only be realized in laboratory practice, but could not be obtained when extended to full-scale industrial operation, due to the amplification on the larger scale of adverse factors, which in the laboratory were so minimized as to be unobservable. Thus, the insulation of the furnace held small amounts of moisture which was impossible to remove and which diffused into the annealing chamber. A certain amount of air or moisture, moreover, leaked and/or diffused into the furnace from the outside atmosphere against the pressure of the hydrogen, or was carried in the furnace in the form of a thin film adhering to the surface of the metal to be annealed. Another supply of moisture was derived from the reduction by hydrogen of other metallic oxides present on the surface of the alloy. The water vapor and other oxidizing impurities which collected in the heating and cooling zones of previous annealing furnaces caused the charge to oxidize. Under these conditions, therefore, there was little to be gained from the use of specially purified gas, because it became contaminated with oxidizing impurities after reaching the furnace. The foregoing disadvantages were further aggravated

by an accumulative effect of the water vapor, oxygen, oxidizing gases, etc. building up in parts of the furnace.

Although many attempts were made to remedy the aforementioned shortcomings, none, as far as we are aware, was entirely successful, produced satisfactory results, and could be carried into practical and economical industrial scale operation.

It is an object of the present invention to provide a procedure which substantially eliminates the disadvantages and shortcomings noted hereinabove, which is simple, practical and economical, and which is capable of being carried successfully on an industrial scale to produce satisfactory and commercially acceptable products.

It is another object of the present invention to provide a procedure whereby metallic material, such as stainless steel, alloys of iron-nickel, chromium-nickel, and other nickel and/or chromium containing alloys may be continuously annealed without substantially affecting the bright surface thereof which has been imparted to the metal by cold rolling, or whereby the above-mentioned alloys may be heat treated and a bright surface imparted thereto during the heating process.

The invention contemplates a very rapid and controlled rate of cooling of the heated material through the critical temperature range in which undesirable oxidation is liable to occur.

The invention also contemplates establishing a complete counterflow of a suitable reducing atmosphere with respect to the travel of the material under treatment, and preventing stratification of said atmosphere.

The invention further contemplates establishing a controlled relationship between the material undergoing treatment and the nature of the gaseous reducing atmosphere.

It is another object of the present invention to substantially prevent the accumulation of harmful impurities in the apparatus in which the material is being treated, and to maintain an effective reducing atmosphere in contact with the material undergoing treatment during its cooling stage.

Another object of the invention is to provide a graphite hearth as a support for the material undergoing treatment.

The invention also provides a non-aqueous

liquid seal at the exit end of the apparatus in order to assist in establishing a positive control of the flow of gas through the furnace and of the reducing nature of the gaseous atmosphere itself.

It is another object of the invention to provide an improved, efficient and simple apparatus in which the above mentioned process can be carried out successfully and economically.

Other objects and advantages of the invention will become apparent from the following discussion taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a longitudinal side elevation of an apparatus partly in section embodying the present invention and capable of carrying the invention into practice;

Fig. 2 is a sectional view on line 2—2 of Fig. 1 illustrating a preferred construction of the heating zone of the apparatus;

Fig. 3 shows a sectional view of the preheating chamber taken on line 3—3 of Fig. 1;

Fig. 4 depicts a sectional view on line 4—4 of Fig. 1 and shows a preferred construction of the cooling chamber of the apparatus;

Fig. 5 illustrates an elevational view of the delivery end of the furnace on a slightly enlarged scale;

Fig. 6 is a sectional view taken on the line 6—6 of Fig. 5;

Fig. 7 is a top elevational view of the flexible graphite hearth showing a part within the hot chamber and a part within the cooling chamber; and

Fig. 8 is a side elevation of the flexible graphite hearth illustrated in Fig. 7.

In general, the invention comprises heating the metallic material to be bright annealed in a suitable reducing atmosphere under controlled temperature conditions, and then rapidly cooling the material from the high annealing temperature to below the critical temperature range in which oxidation of the material is liable to occur. The cooling is effected under certain controllable features of the invention, which cause a very rapid and effective cooling of the annealed material to the desired temperature as it emerges from the heating zone of the apparatus. The cooling is further carried under properly controlled conditions of the gaseous atmosphere which maintain an effective reducing atmosphere in contact with the metal during its cooling stage. The invention also embodies other features, hereinafter more fully described, which maintain a substantially unstratified and positive counter-flow of the gaseous reducing atmosphere with respect to the material undergoing treatment thereby substantially preventing the accumulation of impurities in the apparatus and especially in the cooling chamber thereof.

Referring more particularly to Fig. 1, the apparatus comprises essentially a preheating zone, a heating zone, a cooling zone, and a non-aqueous gas-tight liquid seal, all suitably connected and properly controlled to successfully treat metallic materials according to the principles of the invention. Although only imperceptibly shown in the drawings, the apparatus is preferably set up at an angle to the horizontal with the metal entry end thereof at a higher level than the discharge end. The angle of inclination is maintained preferably less than 5° to the horizontal. An angle of approximately 1° has given satisfactory results in actual practice.

Reference character 4 indicates the furnace proper in which the material undergoing treatment may be heated to any temperature required to accomplish the desired results. Furnace 4 may be of any suitable type and may be heated in any desired manner. Thus, for instance, the furnace may be of the electric resistance ribbon type in which the ribbon elements are mounted on the side walls and on the bottom. In order to insure a better and more flexible temperature control, the furnace is preferably divided in three zones, represented in Fig. 1 by reference characters 4A, 4B and 4C, with a separate temperature controller for each zone; the thermocouples controlling the temperature in each zone are indicated by 5A, 5B and 5C. Repairs and replacements of the ribbon elements may be facilitated by constructing the furnace so that each zone is a separate entity and can be removed in a vertical direction from the bottom which is stationary.

Furnace 4 is preferably provided with a muffle 6 which may be a seamless nickel or metallic tube flattened to a thin or shallow oval. At the metal entry end, muffle 6 is connected by means of a suitable gas tight joint to entry chamber 7 which may be provided with a water jacket 28. The water inlet and the water outlet of water jacket 28 are represented by 10 and 11 respectively.

At the delivery end of the furnace, muffle 6 is connected by means of a suitable gas tight joint to inner shell 8 of a water jacketed cooling chamber which is preferably approximately twice as long as heating chamber 4. For the purpose of effecting a more rapid cooling of the annealed material as it emerges from the heating chamber, inner shell 8 is preferably made of thin metal having good heat conductivity. Rapid cooling may be further facilitated by extending outer shell 9 of the cooling chamber to a point immediately adjacent to the heating chamber, and by locating cooling water inlet 12 at the cooler's junction with the heating chamber. The cooling water may be withdrawn through cooling water outlet 13, which may be placed advantageously at the delivery end of the cooler. An auxiliary water outlet 14 may be provided for the purpose of cleaning and flushing the water jacket whenever necessary.

A suitable support for the material undergoing treatment is provided by hearth 15. We have discovered that it is preferable to use graphitic material for the hearth and that new results can be obtained with such a hearth. Among other features the graphite hearth prevents scratching of the metals or alloys being annealed due to the smoothness and high lubricating properties of graphite and tends to eliminate oxidic substances due to the reducing power thereof.

It was found advantageous to make hearth 15 flexible, for instance by joining together graphite blocks by means of suitable flexible couplings made of heat resisting alloy and sufficiently long to allow ample space for free circulation of the atmosphere around and between the blocks. In this manner, there is freedom of expansion and contraction and there is a substantially complete enveloping of the sheet undergoing bright annealing. The flexible hearth may be extended continuously from the entry end of the apparatus to the discharge end thereof. From the entry end to a point at the junction of the heating chamber with the cooler, the graphite block, for instance, may be approximately 1½" x 1½" x 15" long; 7.

this size may be then tapered down to about $\frac{3}{4}$ " x $1\frac{1}{2}$ " x 15" for the cooling chamber in order to facilitate cooling of the material undergoing treatment. By joining together a sufficient number of graphite blocks both laterally and longitudinally, a hearth of any required width and length may be provided which is flexible at every fifteen inches of its length. Breaking or buckling may be avoided by fixing the hearth only at the entry end of the apparatus to allow for freedom of expansion and contraction with variations in temperature.

The aforesaid flexible graphite hearth is illustrated in Figs. 7 and 8. These graphite blocks 27 are flexibly joined to graphite blocks 38 in any appropriate manner. These blocks are herein shown as being held together by a plurality of connecting pins 41 and 42 and a plurality of connecting links 46 which are preferably made of a heat resisting alloy. A plurality of graphite blocks 39 are joined to the end of blocks 38 by means of a flexible coupling 40 and a plurality of connecting pins 43 and 44. Other sets of graphite blocks 39 are joined to the first set of blocks 39 by means of connecting pins 45 and a connecting link 46.

It is to be noted that hearth 15 may be constructed of other materials besides graphite, and that the apparatus may be equipped with mechanical conveyors. A graphite hearth is preferable, however, because due to its high heat conductivity, it facilitates heating and cooling of the material undergoing treatment, does not scratch the soft metals and alloys being annealed, and is essentially free from other troubles and difficulties inherent to mechanical conveyors when operated at high temperatures.

The entry end of the apparatus may be provided with gas seal 16, which is preferably of the dry gas seal type. For instance, the lower half of the seal may be a block of graphite or a block of wood impregnated with oil or graphite, and the top half may be made of stiff felt about $\frac{1}{2}$ " thick. Both halves may be suitably supported in a metal frame and adjusting screws may be provided to permit adjusting and holding in place of both the graphite block and the felt.

Gas seal 17 of similar construction is also provided at the delivery end of the apparatus. Both the lower and upper halves of this seal may be made of stiff felt suitably supported in metallic frames and provided with adjusting screws. Provisions may be made to flow a light oil, preferably kerosene, continuously on the felts in order to effect better sealing and to afford a lubricating effect between the felts and the metallic material undergoing treatment.

The aforesaid gas seal is illustrated in Figs. 5 and 6. An oil cup 29 is adapted to feed oil through a plurality of tubes 30 to a recess 36 provided in the rear of plate 34 which is in contact with a felt pad 33. The felt pad 33 constitutes the upper seal and is secured to the upper seal plate 34 by means of countersunk machine screws or the like. Underneath felt pad 33 and spaced therefrom by a very small clearance provided for the passage of the metal or alloy being bright annealed is a lower felt pad 33' which is similar to the upper seal felt pad. The lower felt pad is held in place by lower seal plate 35. The upper seal plate and felt pad can be adjusted in any appropriate manner such as by a plurality of screws 31 which are adapted to control the vertical movement. For the purpose of controlling

the horizontal movement of the seal plates and felt pads a plurality of adjusting screws 32 are provided.

The delivery end of the furnace moreover may be provided with nonaqueous liquid seal 18, which may be an oil seal. Either seal 17 or seal 18 give satisfactory results. However, seal 18 is preferably used whenever possible, and seal 17 is used only when treating heavy sections, which do not lend themselves readily to bending around rolls. If seal 17 is used, the cover on the man-hole 19 is removed and the bright annealed metal is allowed to by-pass seal 18. If seal 18 is used, man-hole 19 is closed and seal 17 may be opened up.

A continuous flow of a suitable reducing atmosphere is maintained within the entire length of the apparatus. The reducing gases are preferably admitted to the inner jacket of the cooling chamber at the delivery end of the apparatus and may be discharged at the entry end thereof, thereby establishing a complete counter-flow of the gas with respect to the travel of the metallic strip. The reducing gases are preferably dried before being admitted to the apparatus. For instance, if a mixture of two or more gases is used, such as a mixture of hydrogen and nitrogen or carbon monoxide and nitrogen or the like, the gases may be dried separately in drying towers 20 and 22 for the removal of water vapor and then may be blended in any desired proportion in mixing bottle 24 before being conveyed to the apparatus through gas inlet pipe 25. A proper mixture of the gases may be obtained, for instance, by flowing the dried gases through differential flow gauges 21 and 23, whereby the flow of the gases to mixing bottle 24 may be adjusted and controlled to the desired proportion.

In carrying the invention into practice, as in the bright annealing of metallic strips, one or more coils of the strip may be placed in a coil box suitably located in front of the entry end of the furnace and may be attached to a feeder strip which is usually left in the apparatus when not operating for the purpose of starting the annealing operations. The other end of the feeder strip may be attached through nonaqueous liquid seal 18 to the drum of a suitable coiling mechanism 26 conveniently located in front of the delivery end of the apparatus.

A substantially continuous stream of a suitable reducing gas, properly conditioned as more fully set forth hereinafter is then admitted through gas inlet pipe 25 at the delivery end of the cooling chamber and is allowed to escape at the entry end of the apparatus. If seal 17 is used, the felt pads are pressed firmly against the strip and a light oil, such as kerosene or the like is caused to flow on the felts to afford a lubricating effect between the felts and the metallic strip and to effect as nearly as possible a gas-tight seal. It is generally preferred to use a full non-aqueous liquid seal 18 which presents certain advantages and which make it preferable to seal 17. Thus, for instance, it affords a greater gas economy because of its superior sealing effect. Furthermore, by allowing a greater freedom of movement for the strip, it permits the use of breaker or flattening rolls in continuous operation with the furnace.

At the entry end of the apparatus seal 16 is adjusted to maintain a slight positive pressure within the muffle. It is not essential to have this seal entirely gas tight, because it may be desired to leave an outlet for the reducing gases at the entry end of the apparatus. By controlling the

gas seals at both ends of the furnace in the aforesaid manner, not only a greater economy of the reducing gases may be effected, but a continuous and positive counterflow of the gases is established with respect to the travel of the metallic strip. It was found that a more positive flow of gases could be further effected without any substantial stratification thereof by setting the entry end of the apparatus at a higher level than the discharge end thereof. An angle of inclination of less than 5° is preferable in order to avoid too rapid a flow of gases through the apparatus, thereby producing a "stack effect". An angle of approximately 1° has been found sufficient to substantially avoid stratification of the flowing gases without producing any "stack effect" and to give satisfactory results in actual operation. The air is purged out of the apparatus and then the heating chamber thereof is raised to the desired annealing temperature. The flow of water through the outer jacket of the cooling chamber is regulated to effect the desired cooling of the strip as it emerges from furnace 4. It is to be observed that under normal operating conditions entry chamber 7 is not water cooled and it acts as a preheating chamber for the strip before it enters the furnace proper; water cooling is only resorted to in case of accidents, such as breaking of the strip, when it becomes necessary to withdraw the broken strip backwards through the entry end of the furnace.

After the furnace has reached the proper annealing temperature, coiling mechanism 26 is started and the revolutions are regulated so that the linear speed of the strip is such as to permit the proper interval of time for exposure in the hot zone.

A small amount of air, moisture or other oxidizing impurities may be carried in the furnace as a thin film adhering to the surface of the strip or may diffuse from the outside and leak into the apparatus against the pressure of the reducing atmosphere. Due to the substantially unstratified and continuous flow of the reducing atmosphere from the exit end of the apparatus, the aforementioned impurities including air and moisture tending to oxidize the strip are continually swept back and out of the apparatus and are prevented from penetrating to any great extent into the higher temperature zone of the heating chamber and/or into the cooler.

It was found that surprising results and an accentuated conditioning purification of the atmosphere could be obtained when a graphitic hearth was used. Apparently, the graphite of the hearth tends to react with the oxidizing impurities, such as steam and oxygen, to form carbon monoxide and/or hydrogen thereby affording certain additional protection of the metallic strip.

In the event that a slight oxidation of the metal occurs in the early stages of the operation, reduction of these oxides is accomplished subsequently in the higher temperature zone where the metal is subjected progressively to a purer atmosphere and to a higher temperature.

The temperature of the strip reaches the desired maximum at the exit end of the heating chamber of the furnace. On entering the cooling zone, the highly heated strip is then cooled drastically to below a critical temperature range in which oxidation of the metal is apt to occur. It was found that oxidation is active in the cooling range of about 1400°-1000° F. and that bright annealing of metallic material may be carried out successively provided that the annealed material

was cooled as rapidly as possible to below about 1000° F. and preferably to about 500° F. A rapid and effective cooling of the strip as it emerges from the heating zone is effected by the flow of cooling water which is admitted in the outer jacket of the cooling chamber at its junction with the heating zone in an amount sufficient to maintain the inner jacket substantially at the temperature of the incoming water which is about 70° F. Furthermore, the heat of the annealed metal is transmitted effectively to the cooling water by conduction through the graphite hearth, which has good heat conductivity, and through the inner jacket of the cooler which is made of thin metal of high heat conductivity. A further cooling of the annealed metal is caused by the cool reducing gases which absorb heat from the annealed strip as they flow through the cooling chamber.

The cooling chamber is sufficiently long to dissipate practically all of the heat of the bright annealed strip, thereby permitting handling of the same when delivered through the non-aqueous seal 18.

It is to be observed that, besides facilitating the cooling of the strip, the counterflowing atmosphere furthermore minimizes the tendency of the annealed metal to oxidize during the cooling cycle by bathing the metal with substantially pure atmosphere and by substantially preventing infiltration of oxidizing constituents from the heating chamber into the cooling chamber.

It is to be noted that by affording sufficient freedom of movement of the strip the liquid seal substantially eliminates undesirable mechanical deformation of the metal resulting in a defective surface and permits breaking and flattening rolls to be installed in line with the furnace in order to make the operation more continuous and thereby more economical.

In order to give those skilled in the art a better understanding of the invention, the following specific examples are given for the purpose of illustration.

Cold rolled strips of nickel, "Monel" metal and of a nickel alloy containing approximately 14% chromium and 7% iron, hereinafter referred to as "Inconel", were bright annealed according to the principles of the invention. The operation was carried out in an apparatus similar in construction to the one shown in the drawings and having the following dimensions which represent measurements inside the metallic muffle:

- (a) Entry or pre-heat chamber, 5' 11 3/4" long x 9 1/4" wide x 4" high.
- (b) Heating chamber, 20' 1 1/4" long x 9 1/4" wide x 4" high.
- (c) Cooling chamber, 37' 3" long x 9 3/4" wide x 4" high.

The furnace was electrically heated and the heat input was regulated by three controllers, whose thermocouples were located in the furnace proper so as to divide the chamber into three zones of approximately 6' 8" in length. These zones having separate heat control are represented in the drawings by 4A, 4B and 4C, respectively.

The nickel and "Monel" metal strips were annealed in a mixture of about 88% nitrogen and about 12% hydrogen flowing at a rate of approximately 60 cu. ft. per hour.

The "Inconel" strips were annealed in a hydrogen atmosphere flowing at a rate of approximately 45 cu. ft. per hour.

The following table gives the size of the cold

rolled strips and the annealing speeds and temperatures:

Annealing speeds and temperatures

Type of metal	Thickness of strip	Speed in ft. per min.	Furnace temperatures		
			Zone No. 1	Zone No. 2	Zone No. 3
Monel	.010-.020	9	° F. 1900	° F. 1900	° F. 1900
	.021-.027	9	1980	1980	1980
	.028-.033	8	1980	1980	1980
	.034-.040	7	1980	1980	1980
	.041-.052	6	1980	1980	1980
	.053-.065	5	1980	1980	1980
	.066-.074	4.3	1980	1980	1980
Nickel	.075-.089	3.75	1980	1980	1980
	.090-.110	3.5	1980	1980	1980
	.111 and over	3.25	1980	1980	1980
			° F. 1800	° F. 1850	° F. 1900
Inconel	.010-.032	9	1800	1850	1900
	.033-.044	7	1850	1950	2050
	.045-.055	6	1850	1950	2050
	.056-.065	5	1850	1950	2050
	.066-.075	4.3	1850	1950	2050
	.076-.090	3.75	1850	1950	2050
	.090-.110	3.5	1850	1950	2050
	.110 and over	3.25	1850	1950	2050

It is to be observed that the examples given hereinabove represent actual production runs whereby the cold rolled strips were continuously annealed to produce the required physical properties without substantially affecting the bright surface which had been imparted to the metal by cold rolling.

In regard to the composition of the reducing atmosphere, it is to be noted that nickel and "Monel" metal may be bright annealed satisfactorily in any reducing atmosphere which is substantially free of uncombined oxygen and free of sulphur or of sulphur compounds. When the apparatus is provided with a graphite hearth, however, it is preferable to avoid atmospheres containing other oxidizing constituents such as carbon dioxide and water vapor for the purpose of preventing unnecessary oxidation of the hearth itself.

"Inconel", stainless steel, and other chromium and/or nickel containing alloys may be successfully bright annealed in hydrogen generated by the electrolysis of water. The electrolytic hydrogen may contain about 0.05% oxygen and is relatively high in water vapor. Before use the gas may be dried, for instance in "activated alumina" driers, but it was not found necessary to remove the oxygen content thereof. It is to be observed, however, that "Inconel", stainless steel and the other above mentioned alloys may be bright annealed satisfactorily in any atmosphere containing a minimum of approximately 25% hydrogen and the balance substantially non-oxidizing constituents. Thus, for instance, satisfactory results have been obtained in actual practice when using cracked ammonia gas containing about 75% hydrogen and 25% nitrogen, or mixtures of nitrogen and hydrogen up to about 75% nitrogen and 25% hydrogen, or mixtures of carbon monoxide and hydrogen up to about 75% carbon monoxide and 25% hydrogen.

It is to be observed from the foregoing discussion that the present invention provides an effi-

cient, practical and economical process whereby metallic materials and alloys such as stainless steel, nickel-chromium alloys, nickel-chromium-iron alloys and other chromium and/or nickel containing alloys may be successfully bright annealed on an industrial scale to produce satisfactory and commercially acceptable products.

It is also to be noted that the invention presents certain advantages and embodies certain novel features producing new and unexpected results. Thus, for instance, the invention provides a graphite hearth which substantially avoids scratching of the material undergoing treatment and which is practically free of other disadvantages inherent to mechanical conveyors. Another advantage of the graphitic hearth is due to the good thermal conductivity of the graphite which facilitates the rapid cooling of the annealed material in the cooling chamber. The graphite, moreover, tends to purify the gaseous atmosphere by reacting with some of the oxidizing impurities, such as water vapor or oxygen, thereby protecting the metallic material undergoing treatment from oxidation.

Moreover, a special feature of the invention is the provision of an unstratified and continuous counterflow of the gaseous atmosphere with respect to the travel of the material undergoing treatment, which protects the annealed metal from oxidation during the cooling cycle by maintaining a sufficiently pure atmosphere in the cooling chamber, by substantially preventing oxidizing impurities from collecting in the heating chamber and from diffusing into the cooling chamber, and further by accelerating the cooling of the annealed metal.

It is further to be noted that the invention provides a rapid and effective cooling of the annealed material, as hereinabove described, thereby substantially preventing oxidation of the material during the cooling cycle. The rapid cooling of the metal is facilitated by the cold cooling medium impinging on the cooler at the junction thereof with the hot zone, by the graphite hearth which establishes a contact between the hot material and the cooling medium, and by the counterflow of the gaseous atmosphere.

It is to be observed, moreover, that the non-aqueous liquid seal presents the further advantage of substantially preventing the gaseous reducing atmosphere from being contaminated with water vapor.

Although the present invention has been described in conjunction with preferred embodiment, it is understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Thus, while the invention is especially adapted to the continuous bright annealing of metallic strips, nevertheless it is also applicable to the bright annealing of wires, rods and of other shapes, and of metallic material requiring a conveyor to carry it through the apparatus.

We claim:

1. A furnace for bright annealing metallic products comprising a heating chamber, a cooling chamber connected thereto, and a graphitic hearth extending through said heating chamber and into said cooling chamber.

2. A furnace for bright annealing metallic products comprising a heating chamber, a cooling chamber connected thereto, and a graphitic hearth extending substantially from the inlet end

of said heating chamber to substantially the outlet end of said cooling chamber.

3. A furnace for bright annealing metallic products comprising a heating chamber, a cooling chamber connected thereto, a graphitic hearth extending substantially from the inlet end of said heating chamber to substantially the outlet end of said cooling chamber, means for supplying reducing gases substantially at the outlet end of said cooling chamber and means for withdrawing said reducing gases at the inlet end of said heating chamber.

4. A furnace for bright annealing metallic products comprising a heating chamber, a cooling chamber connected thereto, a graphitic hearth extending substantially from the inlet end of said heating chamber to substantially the outlet end of said cooling chamber, means for supplying reducing gases substantially at the outlet end of said cooling chamber and means for withdrawing said reducing gases at the inlet end of said heating chamber, and means for effecting rapid and controlled cooling of the material undergoing treatment substantially immediately after it leaves the heating chamber.

5. A furnace for bright annealing metallic products comprising a heating chamber, a cooling chamber connected thereto, a graphite hearth extending substantially from the inlet end of said heating chamber to substantially the outlet end of said cooling chamber, means for cooling said cooling chamber whereby a portion of said cooling chamber immediately adjacent to the heating chamber is maintained at substantially the same temperature of the cooling medium, and means for passing a substantially positive and unstratified stream of reducing gases from the outlet end of said cooling chamber to the inlet end of said heating chamber.

6. A furnace for bright annealing metallic products comprising a heating chamber, a cooling chamber connected thereto, said heating chamber and said cooling chamber being upwardly inclined at an angle of about 1° and less than about 5° to the horizontal from the outlet end of said cooling chamber to the inlet end of said heating chamber, a flexible graphitic hearth extending substantially through said heating chamber and said cooling chamber, means for admitting reducing gases at the outlet end of said cooling chamber, means for substantially preventing escape of reducing gases at said outlet end of the cooling chamber, means for controlling withdrawal of reducing gases at the inlet end of said heating chamber, means for cooling said cooling chamber, and means for maintaining the cooling chamber at the junction thereof with the heating chamber at substantially the temperature of the cooling medium.

7. A furnace for bright annealing nickel and/or chromium alloys comprising a heating chamber, a metallic muffle extending through said heating chamber, a cooling chamber provided with a water cooled jacket connected to said metallic muffle, said muffle and said cooling chamber being upwardly inclined at an angle of about 1° and less than about 5° to the horizontal from the outlet end of said cooling chamber to the inlet end of said metallic muffle, a flexible

graphitic hearth extending through said metallic muffle and said cooling chamber, a non-aqueous substantially gas-tight liquid seal at the outlet end of said cooling chamber, means for admitting reducing gases at the outlet end of said cooling chamber, means for controllably withdrawing said reducing gases at the inlet end of said heating chamber and means for admitting cooling water to the water cooled jacket of said cooling chamber at the junction thereof with the heating chamber to maintain said junction at substantially the same temperature as the incoming cooling water.

8. A furnace for the continuous bright annealing of nickel and/or chromium containing alloy strips which comprises a heating chamber, a nickel muffle extending through said heating chamber, a cooling chamber provided with a water cooled jacket connected to the outlet end of said nickel muffle, a preheating chamber provided with a water cooled jacket connected to the inlet end of said nickel muffle, said preheating chamber, nickel muffle and cooling chamber being upwardly inclined about 1° to the horizontal from the outlet end of said cooling chamber to the inlet end of said preheating chamber, a flexible graphitic hearth extending through said preheating chamber, nickel muffle and cooling chamber, a non-aqueous substantially gas-tight liquid seal at the outlet end of said cooling chamber, means for admitting reducing gases at the outlet end of said cooling chamber, means for controllably withdrawing said reducing gases at the inlet end of said pre-heating chamber, means for admitting cooling water to the water cooled jacket of said cooling chamber at the junction thereof with the heating chamber to maintain said junction at substantially the same temperature as the incoming cooling water, means for passing material to be bright annealed through said furnace and means for withdrawing bright annealing material through said non-aqueous seal.

9. A furnace for bright annealing metallic products including nickel chromium alloys comprising a heating chamber, a cooling chamber connected thereto, a metallic muffle extending completely through the heating chamber to form a continuous metallic chamber, a graphite hearth extending completely through the continuous metallic chamber and over which and in contact with which the metal to be bright annealed moves, and means for providing a gaseous atmosphere which is reducing with respect to nickel chromium alloys, which is practically devoid of water vapor and which contains not more than traces of other constituents which would be oxidizing with respect to nickel chromium alloys, and means for flowing the said gaseous reducing atmosphere continuously through the entire metallic chamber in continuous contact with the metal being bright annealed and in a direction opposite to that of the metal throughout its entire movement through the furnace and in volume sufficient to maintain a slight positive pressure within the entire metallic chamber.

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