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APPARATUS AND METHOD FOR PROCESSING OF STEEL STRIP CONTINUOUSLY

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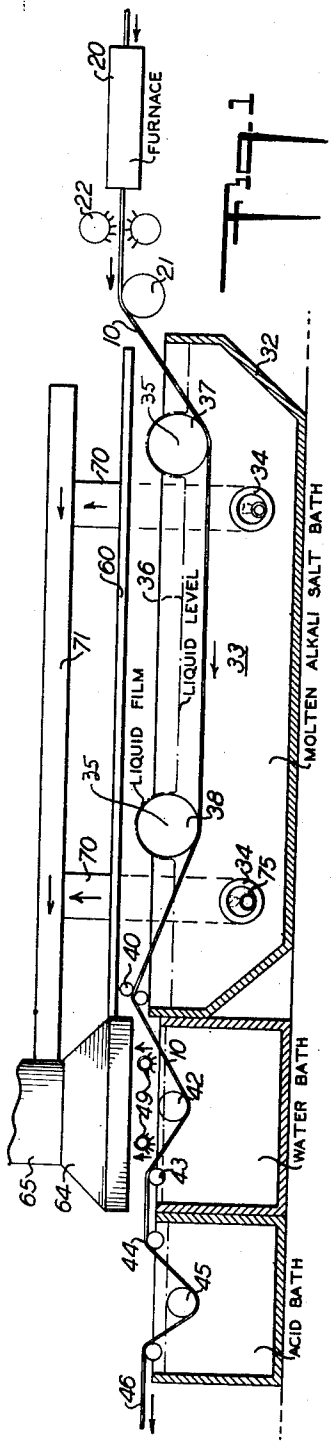

FIG. 1

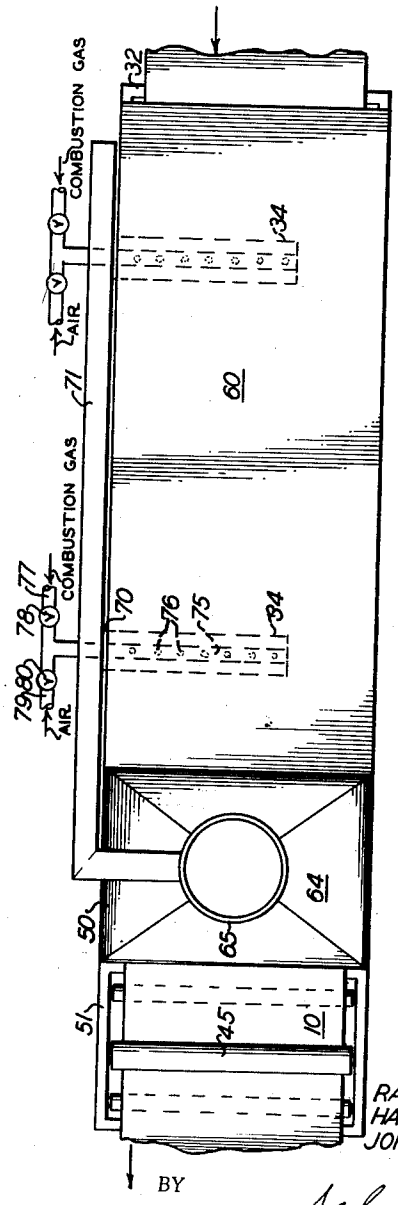

FIG. 2

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APPARATUS AND METHOD FOR PROCESSING OF STEEL STRIP CONTINUOUSLY

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5 Claims. (Cl. 134—3)

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This application relates to apparatus and method for cleaning metal strip continuously and generally relates to apparatus for continuously using a metal cleaning process of the molten alkali salt bath type, a preferred but not necessarily the only example of which is the process known commercially as the K1 process and described in Patent No. 2,458,661 of January 11, 1949 to Hugh G. Webster and Clarence J. Falter.

Generally speaking, the apparatus and method under consideration employs molten alkali salts for cleaning metal strip continuously and includes the use of means for preventing directing and squeeze-out rollers employed in such apparatus from marring or scratching the cleaned surface or the surfaces being cleaned, and also means for preventing the deposit on such rolls of solid particles which would mar or scratch the steel strip.

It is understood that the term "strip" as used herein refers to a moving ribbon of any desired width, not only ribbon under 12" wide and known to the trade as strip, but also ribbon over 12" wide and known to the trade as sheet, and also ribbon extremely narrow and known to the trade as wire.

It is also understood that while steel is the particular metal chosen for descriptive purposes herein, and is more commonly used for treatment by the process hereof, copper may also be treated by the process hereof.

The process

Patent No. 2,458,661 discloses a metal cleaning process of the molten alkali salt bath type wherein a first step is the immersion of the article being treated in a molten alkali salt bath at an operating temperature well above the melting point of the alkali salt, such immersion operating to transform impurities into easily removable oxides. The second step in the process of that patent is the immersion of the oxide coated article, coated with the oxide formed by the first step, into a bath which operates to remove the oxide coating. Such second bath may be itself an alkali metal salt bath or it may be a weak acid bath.

The time of immersion of the article being cleaned in either of these two baths is governed by operating conditions, which also govern the temperatures of the bath. The immersion in the first bath may be of any desired period, in some cases being well below one minute, and in other cases being well in excess of one minute. The immersion in the second bath is generally quite

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brief, only enough to remove the readily removed oxides formed by the first bath. The immersion in the second bath is a variable, depending on the metal being treated.

The temperature of the first bath is also as desired, ranging from somewhere above the melting point of the salt bath, to somewhere below its vaporization point, or its decomposition point, whichever is lower. Where the bath is of the preferred formula, as set forth in Patent No. 2,458,661, the melting point is 550° F. approx., the decomposition point is 1100° F. approx., and the vaporization point is 2500° F. approx., and the bath temperature will be between 500° F. and 1100° F.

Between the first and second baths there is customarily employed a water rinse bath of any suitable type. This insures uniform oxide removal from the strip. It is well known that the presence of alkali (as from the first bath) on a metal surface when immersed in an acid (as in the second bath) tends to prevent oxide removal. The water rinse insures the absence of alkali on the strip from the first bath as the strip enters the second bath.

Inasmuch as the process of the foregoing named patent may readily be understood upon reference to that patent and need not be further described herein, reference to that process generally is here concluded with the observation that the preferred process hereof is identical with the process of that patent and with the understanding that the disclosure of that patent is incorporated into this application by reference, to avoid the necessity of incorporating that disclosure hereinto expressly.

While the process of said patent 2,458,661 is the one preferred for use as the process hereof, other processes and variations of said process may also be used, to the extent disclosed herein.

The apparatus

It is known to employ long troughs with directing rollers to treat strip continuously. Such apparatus is here used for continuously using the process above described on continuously moving strip. However, certain improvements have herein been disclosed and will now be described.

The improvements

The improvements of this application relate to the treatment of continuously moving strip. Such improvements are aimed particularly towards the utilization of rollers for directing and moving strip continuously through the baths and

to the use of means for preventing the deposit on such rollers of solid particles which would mar the finish of the strip as it passes by and engages such rollers.

It can readily be understood to those skilled in the art that the use of rollers for directing and moving strip continuously through molten salt baths, water rinse baths, and oxide removing baths, is a prerequisite. This application specifically relates to the apparatus and the use of such apparatus for preventing deposits on such rollers from marring the surface of the strip engaging and passing by such rollers.

For an understanding of the apparatus and process hereof, and on the assumption that the reader hereof will have become by this time familiar with the process of the aforesaid Patent 2,458,661, incorporated hereinto by reference, reference may now be had to the following specification and detailed description to be read in connection with the accompanying drawing.

In this drawing:

Fig. 1 is a diagrammatic side view of a continuous strip treating apparatus, including a furnace, a molten salt bath, a water rinse bath, and an oxide removing bath.

Fig. 2 is a diagrammatic top plan view of the apparatus of Fig. 1.

Referring now to the drawing, it will be observed that the drawing shows at **10** a continuously moving strip being treated continuously by the process of the aforesaid patent.

The strip is first heated in a furnace **20** in order that its temperature be brought above the operating temperature of the molten salt bath, later to be described. Since the operating temperature of the molten salt bath may range anywhere from 500° F. up to approximately 900° F., depending upon operating conditions and the speed of operation, with the lower end of the range being determined by the operating temperature required for maintaining molten the salt bath, and with the maximum temperature being determined by the temperature above which the salt bath vaporizes or decomposes, whichever is lower, it is generally contemplated to heat the strip in the furnace to a temperature around 1200° F. In some instances even higher temperatures, 1900° F.–2200° F., are used. So heated the strip passes over a directing roller **21**.

It is pointed out here that the aforesaid heating is to a temperature selected as proper for the particular alloy being treated and is not critical to the present invention.

In the event the steel strip leaving the furnace **20** is at too high a temperature, it may be cooled by the use of steam sprayed out of the steam pipes **22** just ahead of the roller **21**. It may be observed here that if the steel is too hot as it enters the molten salt bath, it will cause bubbling and splattering of the molten salt in the bath with undesirable effects. To prevent this result, the steel strip may be cooled by the steam from pipes **22**. Air, water, or air-water-steam mixtures may also be used for cooling the strip in some cases.

In some instances the strip is cooler than the salt bath on entering it. For example, the strip might be entered at room temperature into the salt bath.

The molten salt bath

Next in line to the directing roller **21** is a molten salt bath which includes a tub **32** containing the molten salt **33**, the latter being of the molten alkali salt type. In the preferred process, it is generally of the formula of the aforesaid Patent 2,458,661, namely, 1 part by weight of alkali metal nitrate, 1.5–3.0 parts by weight of alkali metal hydroxide, and 0.1–0.5 part by weight of alkali metal chloride.

The salt **33** is maintained molten by suitable heating means. One suitable heating means is the burning gas tubes **34** which are immersed in the molten salt.

The tubes **34** are merely cylindrical chambers immersed in the salt bath **33** which house elongated ducts or pipes **75**. Pipes **75** supply combustible gas which is burned in a series of small burner flames disposed along the length of each pipe **75** by forming a series of perforations **76** therein through which the combustible gas is emitted and burned. The combustion gas is supplied from any suitable source through a pipe **77** controlled in quantity by a valve **78**, mounted thereon and it is mixed with air passed through a pipe **79** which joins pipe **77** both combustible gas and air mixing and passing into pipe **75**, the air being in combustion supporting quantity as controlled by a valve **80** mounted on pipe **77**. The waste gases after combustion within tubes **34** are led away through tubular ducts **70**, each joining a tube **34** at right angles, and thence into a manifold duct **71** common to all which leads to stack **65** of the vent for ultimate disposal of the waste gases.

Disposed on horizontal axes **35** above the normal level **36** of the molten salt **33** are directing rollers **37**—**38** which direct and move the strip **10** from roller **21** down into the molten salt bath and then to a pair of rollers **40**, later to be described, which in turn direct the steel strip out of the bath **33** and towards rollers **42**, **43**, and **44**, **45**, **46** which direct the strip under a water spray pipe **49** and through a water rinse bath **50** and an acid rinse bath **51**. The acid rinse is here disclosed as the preferred means for removing the oxides formed in the molten salt bath **33**, and is of the character described in the aforesaid patent, 2,458,661, such acid rinse bath being a dilute acid selected from the class consisting of hydrochloric and sulphuric acids, such that the bath will react chemically with the oxidized coating of the steel strip to remove such coating and leave the strip free of the original impurities and of the oxidized coating as well. The immersion in the acid rinse bath is timed, however, to be such as not to expose at the surface other impurities not previously existent or not previously exposed and is sufficiently brief so as not to permit the acid to attack the metal of the steel strip, but merely to remove the oxide coating formed by the molten salt bath itself.

While in the preferred embodiment the acid rinse bath is a dilute acid of the group comprising hydrochloric and sulphuric acids, it has been found, in some cases, practical to use other acids, such as nitric or nitric hydrofluoric acids.

Thus far we have described nothing more than a continuous strip treating process for carrying out the process of the aforesaid patent, such as might be developed by anyone skilled in the art. Now we turn to the improvements of this application.

1. First is the improvement in the nature of the rolls **37**, **38**, and **40**. These rolls are not steel rolls, as are customarily contemplated in baths used for treating continuously moving steel strip, but rather are of cast iron. It was discovered that when steel rolls were utilized, as the rolls

37, 38, and 40, the steel rolls scratched the surface of the steel strip 10, particularly objectionable if that steel strip was polished stainless steel. It was further discovered that when cast iron was used for the surface of such rolls, as by using a cast iron shell on a steel roll, there was formed in the surfaces of the cast iron rolls, minute fissures produced by the removal of the graphitic carbon from the cast iron rolls due to the action of the molten salt on the cast iron rolls. These minute fissures provided excellent reservoirs or pockets for the fluid or molten salt on the rolls and the molten salt was observed to function as a lubricant on the ferritic surface of the cast iron rolls, the fissured rolls functioning in a manner similar to a porous metal roll. The molten salt clinging to the surfaces of these rolls acts as an excellent lubricant and prevents the rolls from scratching the polished stainless steel strip passing by and engaging them.

Similarly, the rolls 40 for squeezing off excess molten salt from the strip 10 leaving the salt bath were also made of cast iron.

While the use of cast iron for the rollers is of special value because of the effect on such rollers of the molten salt bath of Patent 2,458,661, it may here be pointed out that the same beneficial results may be obtained with other salt baths, provided they be of a class or nature as to remove graphitic carbon from cast iron. The latter is the essential or determining factor in the cooperative relationship of the bath and the rollers, cooperating to the end that the rollers will not scratch the strip.

2. However, it was found necessary to provide means for heating the rolls 40 so as to maintain the salt at such rolls in a molten and fluid condition. Obviously, any suitable heating means could be employed. However, it was observed that by providing a rather close fitting insulating cover 60 over the tub 32, the heat radiated from the surface of the molten salt 33, heated by the heating means 34 necessary to maintain such salt molten, operated to maintain the salt molten, even at the rolls 40, and the molten salt on such rolls acted as a lubricant to prevent scratching of the polished stainless steel strip by the rolls 40.

In addition, as long as the salt was maintained molten at the rolls 40, the formation and deposit of alkali carbonates and other crystalline materials on the strip 10 at the rolls 40, and on the rolls 40 themselves, was inhibited and, thus, another cause for marring of the strip was eliminated. It was discovered that unless the salt was maintained molten at the rolls 40, then solid carbonates and other crystalline materials were deposited on such rolls and these caused the scratching of the strip. The provision of the insulating hood 60 operated in the manner above described to prevent the formation of these solid deposits on the rolls 40 and, thus, prevented marring of the strip due to the presence of such solids.

3. Still another improvement is the venting of the water rinse bath 50 as by the provision of a closely fitting venting hood 64 connected to an exhaust fan or the like to outlet at 65. It was observed that in the absence of any vent, such as the vent 64, alkali vapors from the surface of the molten salt, particularly in the water rinse bath 50, condensed, with the condensate settling on the surface of the finished strip passing through such rinse bath in or near such rinse bath and causing surface imperfections. The

provision of the vent 64 prevented such alkali vapors from condensing and coming into contact with the strip and settling on the strip and preventing the marring that would otherwise be the case. Not only does the vent 64 prevent spotting due to the condensed vapors but also vent 64 accelerates removal of the vapors themselves. These vapors, coming into contact with the strip, may cause discoloration. Their rapid removal, by vent 64, inhibits such action.

4. Still another improvement is in the location of the water rinse tank. This tank is located as close to the molten salt bath as possible. It has been discovered that improved results, with respect to the preventing of imperfections and discolorations on the stainless steel strip, may be obtained by decreasing the distance between the point where the strip leaves the molten salt bath and the point where it enters the water rinse bath.

By providing the water rinse bath as close to the molten salt bath as possible, it becomes possible to rinse the strip at the highest possible temperature, and this insures superior rinsing with less facilities. The quench action of the rinse is more rapid than otherwise, and this aids in loosening the oxide at the surface and facilitates the removal of the oxide in the weak acid bath 51.

It is noted that the strip is cooled before it reaches roller 42, which is rubber covered. This is accomplished by passing the strip through the bath 50 before it reaches roller 42, or by providing water spray means ahead of roller 42.

5. Still another improvement is in the provision of means for preventing the products of combustion of the burners 34 from coming in contact with the surface of the salt bath 33. The outlets of the burners 34 are connected through outlet pipes 70 and a manifold 71 to the vent 64, so as to be exhausted without coming in contact with the molten salt bath 36.

It has been discovered that if the products of combustion in the burners 34 come in contact with the surface of the salt bath 33, there are formed carbonates which deposit on the rolls 37 and 38 and cause marring of the surface of the strip. The provision of the outlets 70 and 71 for these products of combustion eliminates such carbonates and eliminates this cause for marring the strip.

6. It is noted that the salt bath is as close to the furnace as possible so as to reduce the heat loss in the strip as it passes from the furnace to the salt bath, and thus reduces the cost of fuel for maintaining both the strip and the salt bath at the operating temperature for the bath, whatever that temperature is.

It is also noted that the salt bath, generally below 900° F. in temperature, functions as a quench for the higher temperature steel strip and is located close enough to the exit end of furnace 20 as to receive the strip within two minutes from the time the strip leaves such furnace. Thus it functions to prevent carbide precipitation, when the strip is of stainless steel of the nickel chrome type. Such precipitation, an undesirable phenomenon, occurs when strip of stainless steel of the nickel chrome type is left at 900° F. or above for more than two minutes. The quench action of the salt bath occurs within two minutes because the bath is located so close to the furnace and prevents such carbide precipitation.

Summary

We have here disclosed apparatus for produc-

ing cleaned and scratch-free surfaces on continuously moving strip, such as polished stainless steel strip. The process herein disclosed is the KI process described in the aforesaid Patent 2,458,661. The apparatus hereof contains certain improvements listed as follows:

(1) The use of cast iron surfaces for the hold-down, directing, and squeeze-out rollers in the molten salt bath.

(2) The use of an insulated cover or hood for the salt bath at the squeeze-out rollers to maintain the molten salt fluid at such rollers.

(3) The use of a shield and ventilator for the water rinse immediately following the molten salt bath.

(4) The outletting of the products of combustion of the burners used for heating the molten salt bath away from the salt bath so as to prevent these products from coming into contact with the salt bath and forming carbonates and the like to deposit on the rollers and cause scratching of the strip.

(5) The locating of the salt bath as close as possible on the one hand to the strip heating furnace, and on the other hand to the water rinse following the salt bath.

Now having described the invention of this application and the construction shown in the appended drawing, reference should now be had to the claims which follow.

We claim:

1. The combination, in apparatus for cleaning the surfaces of metal strip by passing the same through a liquid bath comprising molten alkali metal salts, of an atmospherically open tank containing said molten alkali metal salts, and a pair of tangential metal rollers mounted in the after end of said tank above the surface of said molten salt receiving in the nip between said rollers said molten salt coated metal strip to support, guide and squeeze excess salt from said strip as it emerges from said salt bath, whereby said salt would tend to cool and freeze on the surfaces of said tangential rollers and thereby scratch and mar the surface of said clean metal strip by abrasion of the solidified salts thereon and means to heat said rollers to a temperature sufficiently high to maintain the salt molten as a film about said rollers.

2. The combination, in apparatus for cleaning the surfaces of metal strip by passing the same through a liquid bath comprising molten alkali metal salts containing an oxidizing agent reactable with graphitic carbon, of an atmospherically open tank containing said molten alkali metal salts, a pair of tangential cast iron metal rollers mounted in the after end of said tank above the surface of said molten salt to support, guide and squeeze excess salt from said metal strip as it emerges from said salt bath,

said cast iron rollers having a normal content of graphitic carbon which has been fissured by reaction with the oxidizing component of said bath whereby the surface of said fissured cast iron, by removal of said graphitic carbon, entrains in said fissures the salt of said bath as a non-abrading lubricating film about said rollers in non-abrasive contact with said metal strip when said salt is maintained as a liquid film and means for maintaining said rollers in a sufficiently highly heated state to maintain said salt liquid.

3. Apparatus as defined in claim 1 wherein said means for maintaining said rollers at a temperature sufficiently high to prevent solidifying of the salt comprises a metallic heat reflecting shield mounted above said bath to be heated by heat radiated from the bath and reflected by the shield against said rollers to maintain the high temperature thereof.

4. Apparatus as defined in claim 2 wherein said means for maintaining said rollers at a temperature sufficiently high to prevent solidifying of the salt comprises a metallic heat reflecting shield mounted above said bath to be heated by heat radiated from the bath and reflected by the shield against said rollers to maintain the high temperature thereof.

5. The method of operating a metal cleaning bath of the molten alkali metal salt type comprising melting into an atmospherically open bath an alkali metal salt containing an oxidizing agent reactable with graphitic carbon, mounting above the surface of said bath a pair of cast iron tangential guide rollers adapted to guide, support and squeeze excess molten salt from said strip as it leaves said bath, said cast iron rollers having a normal graphitic carbon content reactable with said oxidizing agent forming fissures in the surface of said rollers by removal of said graphitic carbon and continuously mechanically entraining in said fissured rollers a non-abrading lubricating film of said molten salt in non-abrading supporting and guiding contact with said metal strip, reflecting heat from the bath upon said rollers to maintain the same sufficiently hot to prevent freezing of the salt film about said rollers and continuously guiding metal strip to be cleaned through said bath and through the nip of said rollers.

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