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APPARATUS FOR HANDLING METALLIC STRIP

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FIG. 1.

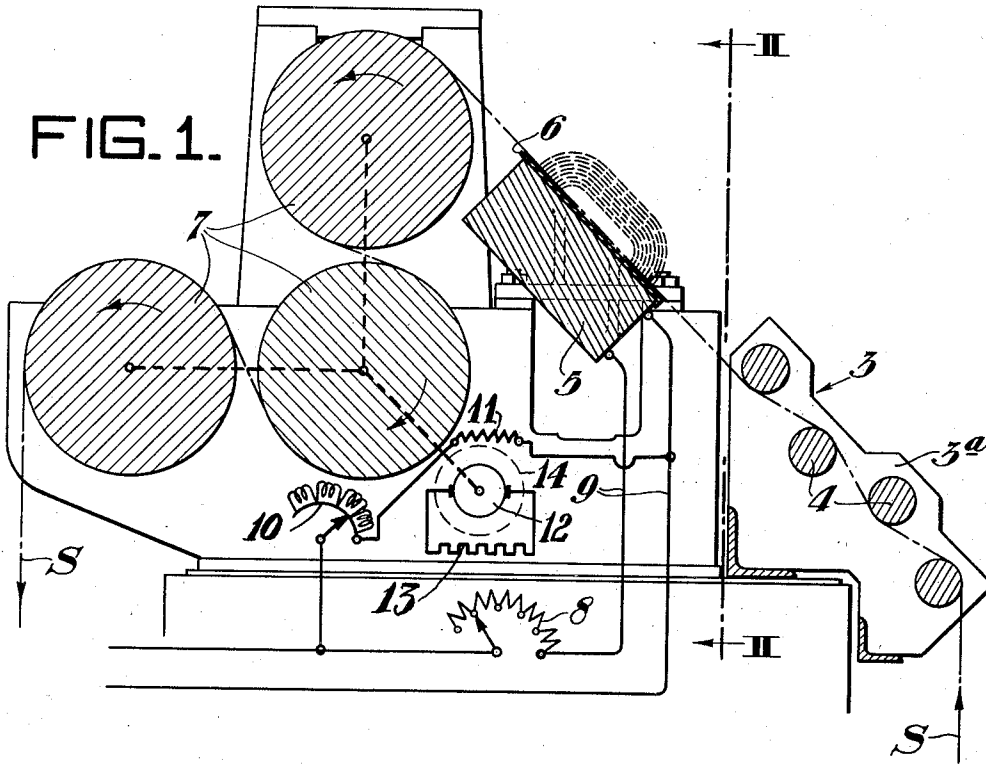
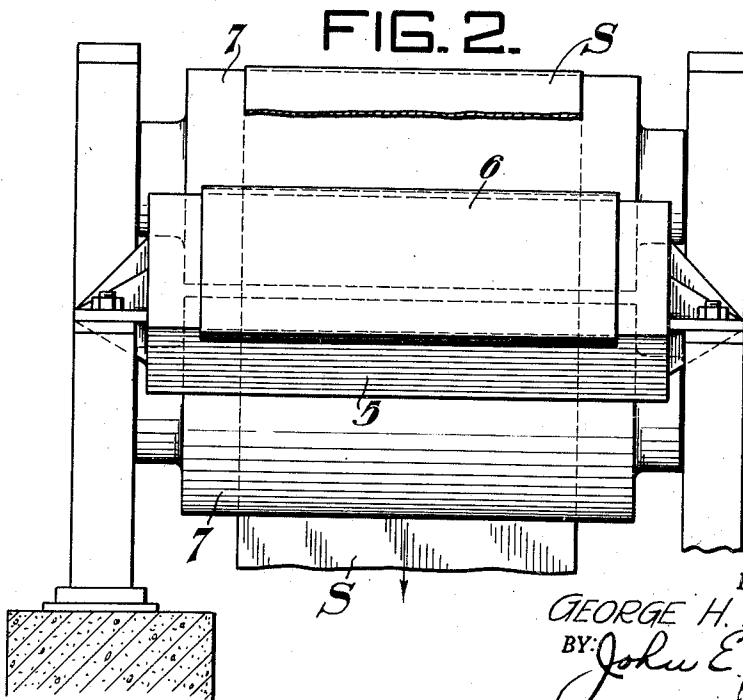


FIG. 2.



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APPARATUS FOR HANDLING METALLIC STRIP

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9 Claims. (Cl. 271—2.1)

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In accordance with the present invention, there are provided certain improvements in the handling of metal strip, especially thin strips of ferrous metal or steel preparatory to the application of another metal thereto.

More specifically, the present invention relates to apparatus for insuring proper introduction of rapidly moving thin ferrous strip into electrolytic cells where the strip receives a coating of tin. It will be remembered that the stock which is employed customarily in an electrolytic tinning operation is very thin, being of the order of only at most a few hundredths of an inch in thickness, and is passed through the electrolytic coating cells at speeds up to a thousand feet a minute.

The manner in which such strip is handled prior to its entry into the electrolytic coating system is important in assuring that the rapidly moving strip is maintained continuously under suitable conditions in the electrolytic cell for receiving a uniform deposit. One of these conditions that is requisite for the production in a uniform electrolytic coating is the measurements of the rapidly moving strip continuously at a constant distance from the anodes in the coating system, which means that the tension on the strip throughout its passage through the plating system is an important consideration, because the measurements of a controlled constant tension on the strip results in the maintenance of a constant speed of strip through the system and the maintenance of a constant distance from the anodes in the plating system. There are maintained, consequently, continuously constant conditions in the cell, which conditions are related directly to the amount of tension which is applied to the strip as it enters the plating system.

A commercial electrolytic tinning line for electrolytically coating ferrous metal strip with a coating of tin includes various units. Thus a commercial tinning line includes units for welding together successive ends of strip which is being fed through the apparatus, pickling units, washing units, plating cells, and finally heating means for rendering the applied coating homogeneous and bright, which may be done in a variety of ways such as by a fusion of the tin coating. The strip is fed through the system as a continuous strip of indeterminate length, ends of successive strip being welded together without interruption to the progress of the strip through the system as

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the operation continues. There is employed single motivating means for pulling the strip through the entire line, the motivating means comprising a roll bridle at the forward end of the line which pulls the strip through the entire system of units at constant and controlled speed.

As has been pointed out above, the tension under which the strip is introduced into the coating system is an important factor in the maintenance of continuously constant conditions in the coating system; and the present invention relates specifically to apparatus for handling such strip which assures controlled and constant tension on the strip as it enters the electrolytic system.

In general terms, the present invention relates to a combined magnet and drag bridle for maintaining the correct and controlled back tension on metallic strip, particularly rapidly moving ferrous metal strip which is being passed through an electrolytic tinning system, although the invention is not limited to such specific application.

In general, the object of the present invention is to provide flexible means for retarding the forward movement of continuous and continuously moving ferrous metal strip which is being conveyed from a substantially untensioned point on a preceding processing device so that the strip will be maintained under a controlled back tension greater than that produced by a conventional bridle mechanism between the point at which the restraining force is applied and the point at which the strip is given its forward movement through intermediate processing devices, such as, for example, the aforementioned electrolytic coating system.

The invention will be understood more readily by referring to the accompanying drawings, wherein:

Fig. 1 is a sectional elevation of the apparatus for handling metallic strip from preceding processing equipment, the view being directed only to the particular part of the entire system to which the present improvements are applied;

Fig. 2 is a side elevation of the apparatus of Fig. 1 taken generally along the line II—II of Fig. 1, looking in the direction of the arrows.

Referring more particularly to the drawings, a continuous strip S of metallic material is indicated as coming from a slack producer looper pit and passing through a roller side guide device 3, which guide device includes a plurality of stag-

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geredly arranged rollers 4, these rolls causing the continuous strip S to pass in a tortuous path therethrough.

Due to the tortuous path of travel of the ferrous metal strip S through the guide device 3, a stiffness is imparted to the thin strip, which permits it to be laterally positioned by metal plates 3^a on each side guide. The strip then passes over an electromagnet 5, which, by reason of the magnetic flux set up by the electromagnet 5, holds the under surface of the strip in intimate contact therewith. In order to prevent scratching of the strip during its passage over the electromagnet 5, and also to assure the maximum coefficient of friction between the magnet 5 and the strip S, there is provided upon the contact surface of the magnet 5 a non-abrasive facing material 6 such as, for example, cloth or other fibrous material, or any other friction-producing material which will not abrade the surface of the strip. This creates a controlled "initiating tension" on the strip, this tension being dependent mathematically on a magnetic pull and coefficient of friction between the friction pad 6 and the strip S.

Positioned adjacent to the magnetic drag, or tensioning, device 5, is a drag bridle which includes a plurality of drag bridle rolls 7, around which the strip S is passed, as shown in the drawings. The bridle rolls 7 are driven in unison by the movement of strip S around the rolls, which rolls are connected to suitable braking instrumentalities, which, for example, may be an electric generator, the output of which can be regulated, or by means of mechanical, hydraulic, or other means, acting on bridle rolls 7 to retard the rotation thereof.

Thus, as may be seen from Figure 1, an electric generator 14 is connected by means of suitable gearing, to the bridle rolls 7, which may be geared together, as indicated diagrammatically on the drawing. As the strip S passes over the magnet 5 and around the drag bridle rolls 7, the strip acts as a belt, thus causing the rolls 7 to rotate, thereby revolving armature 12 of generator 14. Dynamic braking of the rolls 7 is accomplished by a load resistor 13, which is connected in parallel with armature 12. Rotation of armature 12 in the magnetic field produced by field winding 11, generates an electric current which is dissipated in the load resistor 13, thereby restraining the forward rotation of the bridle rolls.

The electrical output of generator 14 may be regulated by adjusting the electrical strength of the field winding 11. The field winding 11 may be regulated in any suitable manner such as by a rheostat 10 connected in series with field winding 11 and connected in circuit across a power supply 9. Where the bridle rolls 7 are geared together, only one such arrangement needs to be employed; and consequently, it is preferred that the bridle rolls be geared together. However, in the event that the bridle rolls are not geared together, a separate dynamic braking mechanism similar to that described above and shown in Figure 1 is supplied for each roll.

By reason of the resisted motion of the bridle rolls 7 and the intimate contact of the ferrous metal strip to the rolls, maintained by the tensioning action of the magnetic drag on the strip, the free forward movement of the strip is restricted. The amount of restricting force is directly proportional to the area of surface contact between the strip and the rolls, the coeffi-

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cient of friction at the said surface, and the force acting normally to the surface of the roll which holds the strip in intimate contact therewith. By such a bridle construction, the restraining force after the ferrous metal strip has passed over the last roll of the bridle, is materially greater than the restraining force applied to the strip as it initially passes over the first roll of the bridle. By the present invention it is possible to minimize the number of rolls used in the bridle construction, and still obtain an increase in the restraining force over that obtainable by the drag bridle alone of the same design if employed without the cooperating initiating tension magnet 5 and its friction pad 6. This result is possible with the combination of the elements of the present invention due to the fact that the initial restraining force is applied to the strip before it enters the drag bridle. The initiating tension applied to the strip material by the electromagnet 5, in conjunction with the mechanical advantages obtained by the bridle, results in a marked increase in the total restraining force applied to the strip S by its passage over the bridle, and assures constant conditions of tension of the strip as it passes through the electrolytic system, with attendant constancy of conditions in the electrolytic system, and in the succeeding units through which the strip passes to its finished stage.

The flux density of the magnet 5 may be controlled readily in any manner well-known in the art, such as by a rheostat 8 included in the current supply line 9, which connects the magnet 5 to a suitable source of current, not shown. This permits both flexibility and ease of control of the initiating tension applied to the strip by the magnet 5. In this manner, the total restraining force applied to the strip by the bridle rolls likewise may be controlled.

In any case, the initiating tension applied to the strip by the electromagnet 5 results in a snubbing effect on the strip, causing it to be pulled tightly against the entry bridle roll and preventing slippage between the strip and the bridle roll.

The magnetic drag for producing the initiating tension on the strip, is applied to only one side of the strip, thereby allowing all irregularities, such as cambered strip, wavy edges, dents, welded or otherwise joined coiled ends to pass freely over the tensioning magnet; whereas, if the restraining force were applied by a mechanical device operating on both sides of the strip, such irregularities would tend to pile up and cause the strip to be gouged, torn, folded over, or otherwise deformed, as well as tending to tear out, or otherwise damage, the restraining mechanism.

The relationship between the initiating tension magnet 5 and the bridle roll 7 may be expressed mathematically as follows:

I. For control of initiation tension:

$$T_1 = T_2 + Pu_1 \quad (\text{Equation 1})$$

where

P = Total pull of magnet on strip
 u_1 = Coefficient of friction between strip and pad
 T_1 = Tension of strip after passing over magnet
 T_2 = Tension of strip before passing over magnet

Normally T_2 is very small compared to the tension T_1 attained by use of the magnet, hence the tension imparted to the strip can be closely expressed by the formula.

$$T_1 = Pu_1 \quad (\text{Equation 2})$$

II. The controlled initiating tension is then

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multiplied by use of the roll bridle which, when geared to a suitable drag device such as a generator, will act as a dynamic brake. Such an arrangement can magnify the controlled tension imparted to the strip according to the following mathematical relationship:

$$F = \frac{1}{e^{u_2 \theta}} = \frac{T_1}{T_3} \quad (\text{Formula 3})$$

where

F=Ratio of controlled initiating tension

T₁=Controlled initiating tension

T₃=Capacity tension

e=Base of natural logarithms

u₂=Coefficient of friction between the strip and the bridle roll surface

θ=Aggregate angle of contact of the strip and all the bridle rolls (expressed in radians)

Combining both of the above phases of the strip tension control principle (Equation 2 with Equation 3), the capacity tension which all rolls of any one bridle can exert is related to the pull of the magnet as follows.

$$F = \frac{1}{e^{u_2 \theta}} = \frac{T_1}{T_3}$$

or

$$T_3 = P u_1 e^{u_2 \theta}$$

where

F=Ratio of controlled initiating tension to capacity tension

T₁=Controlled initiating tension

T₃=Capacity tension

u₁=Coefficient of friction between the strip and the magnet pad

e=Base of natural logarithms

u₂=Coefficient of friction between the strip and bridle rolls

θ=Total angular wrap on bridle rolls (expressed in radians)

While there has been shown and described herein a specific embodiment of the present invention, it will be apparent that the invention is not limited to the exact embodiment herein illustrated and described, since various modifications may be made without departing from the scope of the invention, as defined by the following claims.

The present application is a continuation of the copending application Serial No. 270,700, filed April 23, 1939, entitled "Handling metallic strip," which has become abandoned.

I claim:

1. Tension apparatus for use with strip-moving means adapted to move a strip of magnetic material through strip handling instrumentalities, which comprises a plurality of spaced-apart rotatable rolls around which the strip is adapted to be passed for imparting tension to the strip, magnetic initiating tension means adjacent to the entry side of the said rolls, the said magnet means being constructed and arranged to impose an initiating tension on the strip for holding the strip constantly in engagement with the said rolls under a predetermined controlled initiating tension, and means for guiding the said strip against sidewise movement, the said magnet means having a strip-engaging surface in a direct line with the strip-engaging surface of the initial roll of the bridle.

2. Tension apparatus for use with strip-moving means adapted to move a strip of magnetic material through strip handling instrumentalities,

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the said apparatus comprising a bridle including a plurality of spaced-apart rotatable rolls around which the strip is adapted to be passed, a magnetic drag adjacent to the entry side of the said rolls, the said magnetic drag being constructed and arranged to impose an initiating tension on the strip and to maintain the resulting initiatingly-tensioned strip in tight engagement with the said rolls under a predetermined tension, the magnetic drag being in contact with only one side of the strip, and a friction facing on the magnetic drag for engaging the strip to impart maximum possible friction on the strip while avoiding defacing of the strip, thereby imparting the said initiating tension on the strip, the said magnetic drag having a plane strip-engaging surface in a direct line with the strip-engaging surface of the initial roll of the bridle.

3. Tension apparatus for use with strip-moving means adapted to move a strip of magnetic material through strip handling instrumentalities, the said apparatus comprising a bridle including a plurality of spaced-apart rotatable bridle rolls around which the strip is adapted to be passed, an electromagnet adjacent to the entry side of the said rolls adapted to engage the strip and to impose an initiating tension on the strip for maintaining the strip in tight engagement with the said bridle rolls under a predetermined controlled tension, the magnet being in contact with only one side of the strip, a friction facing on the magnet for engaging the strip to impart maximum possible friction on the strip while avoiding defacing the strip, thereby imparting the said initiating tension on the strip, the said friction facing on the magnet having a strip-engaging surface in a direct line with the strip-engaging surface of the initial roll of the bridle and means for controllable varying current to the magnet for controlling the said initiating tension on the strip.

4. Tension apparatus for use with strip moving means adapted to move a strip of magnetic material through strip-handling instrumentalities, the said apparatus comprising a bridle including a plurality of spaced apart rotatable bridle rolls around which the strip is adapted to be passed, an electromagnet adjacent to the entry side of the said rolls adapted to engage the strip and to impose an initiating tension on the strip for maintaining the strip in tight engagement with the said bridle rolls under a predetermined controlled tension, the magnet being in contact with only one side of the strip, a friction facing on the magnet for engaging the strip to impart maximum possible friction on the strip while avoiding defacing the strip, thereby imparting the said initiating tension on the strip, the said friction facing being in a direct line with the strip-engaging surface of the initial roll of the bridle and means for supplying controllable varying current to the magnet for controlling the said initiating tension on the strip, the initiating tension on the strip being controlled in accordance with the equation $T_1 = T_2 + P u_1$

where

P=total pull of magnet on strip,

u₁=coefficient of friction between the strip and friction pad,

T₁=tension of strip after passing over magnet, and

T₂=tension of strip before passing over magnet.

5. Tension apparatus for use with strip moving means adapted to move a strip of magnetic

material through strip-handling instrumentalities, the said apparatus comprising a bridle including a plurality of spaced-apart rotatable bridle rolls around which the strip is adapted to be passed, an electromagnet adjacent to the entry side of the said rolls adapted to engage the strip and impose an initiating tension on the strip for maintaining the strip in tight engagement with the said bridle rolls under a predetermined controlled tension, the magnet being in contact with only one side of the strip, a friction facing on the magnet for engaging the strip to impart maximum possible friction on the strip while avoiding defacing the strip, the facing being in direct line with the strip engaging surface of the initial roll of the bridle, thereby imparting the said initiating tension on the strip, means for dynamically braking the said bridle rolls, and means for supplying controllable varying current to the magnet for controlling the said initiating tension on the strip, the initiating tension magnet and the bridle rolls having a relationship between them in accordance with the following mathematical equation:

I. For control of initiating tension:

$$T_1 = T_2 + Pu_1$$

where

P=the total pull of the magnet on the strip

T_1 =tension of the strip after passing over the magnet

T_2 =tension of strip before passing over the magnet.

the said controlled initiating tension being multiplied by the dynamically braked bridle rolls, the said bridle rolls thereby magnifying the controlled initiating tension imparted to the strip in accordance with the mathematical relationship:

$$(II). \quad F = \frac{1}{e^{u_2 \theta}} = \frac{T_1}{T_3} = \frac{Pu_1}{T_3}$$

where

F=ratio of controlled initiating tension to capacity tension

T_1 =Controlled initiating tension

T_3 =Capacity tension which all of the rolls of the bridle can exert

P=Total controlled pull of magnet on the strip

u_1 =Coefficient of friction between the strip and the magnet pad

e=Base of natural logarithms

u_2 =Coefficient of friction between the strip and the bridle rolls

θ =Total angular wrap of strip on bridle rolls, expressed as radians

and wherein T_2 of Equation I is negligible in magnitude.

6. Tension apparatus for use with trip moving means adapted to move a strip of magnetic material through strip-handling instrumentalities, the said apparatus comprising a bridle including a plurality of spaced-apart rotatable bridle rolls around which the strip is adapted to be passed, means for dynamically braking the bridle rolls, an electromagnet adjacent to the entry side of the said rolls adapted to engage the strip and to impose an initiating tension on the strip for maintaining the strip in tight engagement with the said bridle rolls under a predetermined controlled tension, the magnet being positioned adjacent to one side of the strip, a friction facing on the magnet for engaging the strip to impart

maximum possible friction on the strip while avoiding defacing the strip, the friction facing being in direct line with the strip-engaging surface of the initial roll of the bridle, thereby imparting the same initiating tension on the strip, the said bridle rolls being related to the pull of the magnet in accordance with the mathematical relationship:

$$T_3 = Pu_1 e^{u_2 \theta}$$

10. where

T_3 =Capacity tension of the bridle rolls

P=Total controlled pull of magnet on the strip

u_1 =Coefficient of friction between the strip and the magnet pad

15. e=Base of natural logarithms

u_2 =Coefficient of friction between the strip and the bridle rolls

θ =Total angular wrap of strip on the bridle rolls, expressed in radians

20. 7. Tension apparatus for use with strip-moving means adapted to move a strip of magnetic material through strip-handling instrumentalities, which comprises, in combination, a drag bridle including a plurality of spaced-apart bridle rolls around which the strip is adapted to be wrapped for imparting tension to the strip, means for braking the bridle rolls, one of the rolls being an entry roll over the upper surface of which the strip is initially wrapped as it enters the drag bridle, means for guiding the said strip against sidewise movement, and magnetic initiating tension means adjacent to the entry side of the said rolls, the said magnetic means being disposed on one side of its strip and having a non-abrasive friction pad mounted thereon, the said pad having its face in direct line between the strip-wrapping surface of the entry roll and the said guide means, the said drag bridle multiplying the initiating tension imparted by the magnetic means through action of the braking means.

30. 8. Tension apparatus for use with strip-moving means adapted to move a strip of magnetic material through strip-handling instrumentalities, which comprises, in combination, a drag bridle including a plurality of spaced-apart bridle rolls around which the strip is adapted to be wrapped for imparting tension to the strip, means for braking the bridle rolls, one of the rolls being an entry roll over the upper surface of which the strip is initially wrapped as it enters the drag bridle, means for guiding the strip against lateral movement, and magnetic initiating tension means adjacent to the entry side of the said rolls, the said magnetic means being disposed on one side of the strip and having a flat face in direct line between the strip-wrapping surface of the entry roll and the said guide means, the said drag bridle multiplying the initiating tension imparted by the magnetic means through action of the braking means.

9. Tension apparatus for use with strip-moving means adapted to move a strip of magnetic material through strip-handling instrumentalities, which comprises, in combination, a drag bridle including a plurality of spaced-apart bridle rolls around which the strip is adapted to be wrapped for imparting tension to the strip, one of the rolls being an entry roll over the upper surface of which the strip is initially wrapped as it enters the drag bridle, and instrumentalities for imparting an initiating tension to the strip prior to its entry into the drag bridle, the said instrumentalities comprising a magnet and co-

75 operating guide mechanism for guiding the strip

against lateral movement, one of the initiating-tension instrumentalities being adapted to increase the tension imparted to the strip by the other, the said magnet having a flat surface in alignment with the guide mechanism and with the strip-wrapping surface of the entry roll of the drag bridle, whereby increase of tension on the strip in the drag bridle avoids separation of the strip from the face of the magnet, a constant contact of the strip and magnet thereby being continuously maintained.

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