June 20, 1939. T. F. BAILY 2,162,692

CONTINUOUS STRIP FURNACE

Filed Nov. 11, 1935

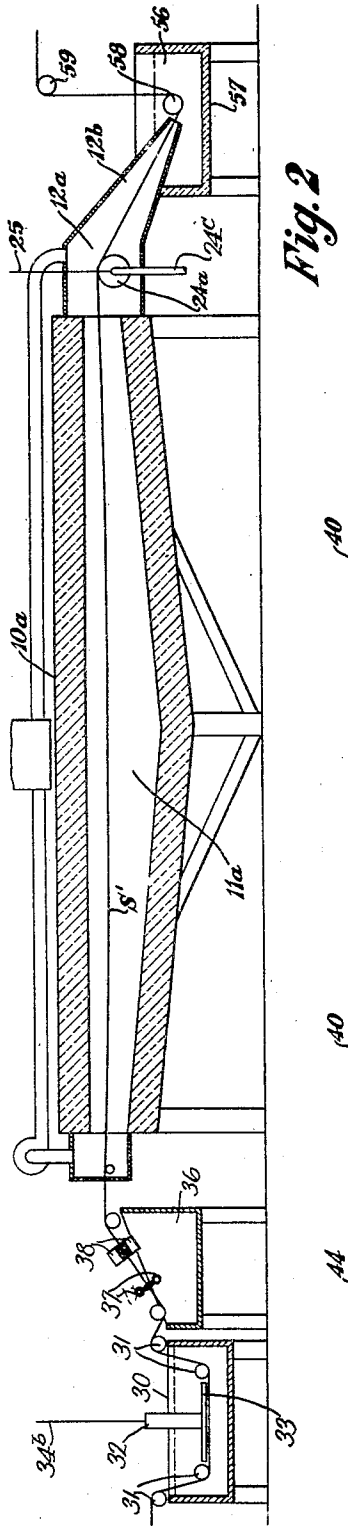

Fig. 2

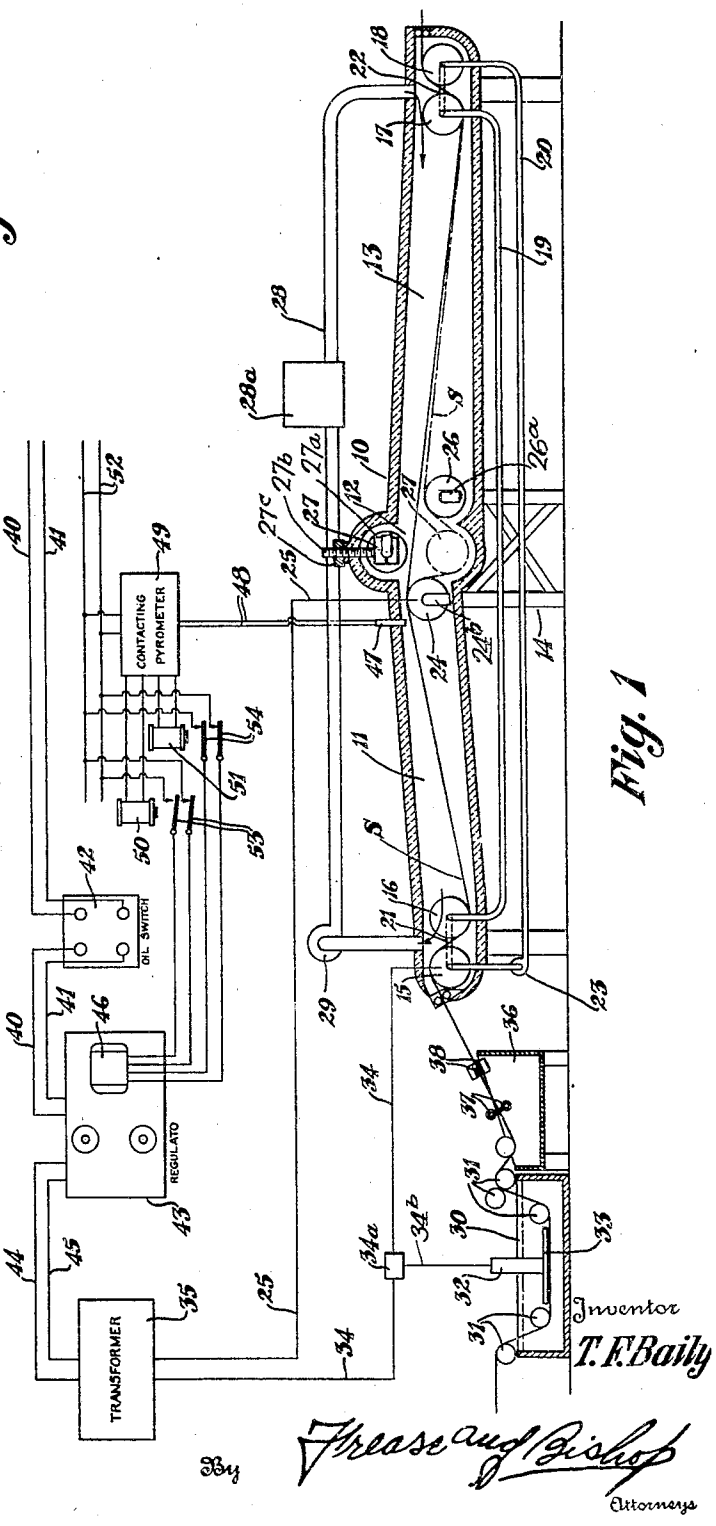

Fig. 1

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Patented June 20, 1939 2,162,692

UNITED STATES PATENT OFFICE

2,162,692

CONTINUOUS STRIP FURNACE

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Application November 11, 1935, Serial No. 49,126

9 Claims. (Cl. 266—3)

The invention relates to continuous furnaces for the heating, heat treating, annealing or coating of metal strips and more particularly to furnaces in which the heating of the strip is produced by electric current passed through the strip.

An object of the invention is to provide a furnace of this general character in which the strip is continuously passed between two contacts in an electric circuit, one contact being a roller and the other contact being an aqueous bath through which the strip is passed before entering the furnace.

A further object is to provide such a furnace in which the roller contact may be water cooled and adjustable to vary the cooling of the strip.

A further object is to provide a furnace of this type in which the aqueous bath may be a pickling solution or the like, means being provided between the aqueous bath and the furnace for washing and drying the strip before it enters the furnace.

A further object of the improvement is to provide means controlled by the temperature of the strip for varying the power input to the strip without interrupting the current.

Another object is to provide rolls at opposite ends of the furnace between which water or other fluid is continuously circulated for purpose of recuperation.

The above objects together with others which will be apparent from the accompanying drawing and the following description, or which may be later referred to, may be attained by constructing the improved furnace in the manner illustrated in the accompanying drawing, in which

Figure 1 is a diagrammatic longitudinal sectional view of an annealing furnace embodying the invention; and

Fig. 2 is a similar view of a metal coating furnace embodying the invention.

Similar numerals refer to similar parts throughout the several figures of the drawing.

Referring first to the construction illustrated in Fig. 1 of the drawing, an elongated hood or tunnel is provided, indicated generally at **10**, and preferably constructed so as to form a heating chamber **11**, an initial cooling chamber **12** and a final cooling chamber **13** of considerable length as compared with the initial cooling chamber **12**. This hood or tunnel may be provided with any suitable and well known lining of heat insulating material and may be supported above the floor by any suitable framework such as indicated generally at **14**.

At the entrance end of the hood or tunnel is located a pair of rolls indicated at **15** and **16**, between which the incoming strip, indicated at S, is passed, these rolls preferably being hollow and provided with means for circulating water or other fluid therethrough.

One or both of these rolls may be used as contact rolls as shown in Fig. 1, in which case a switch **34a** may be provided for connecting either the roll **15** or the electrode **32** or both in the circuit **34**. Where either or both of these rolls is to be used for electric contact with the strip, the diameter of the roll should be at least two hundred times the thickness of the strip under treatment and should have a contact area between the strip and the roll of at least four times the cross sectional area of the strip. It should also be understood that where the roll is used for contact, both the strip and roll should be bright and clean and maintained in a nonoxidizing atmosphere. If only the roll is used for contact the strip may be cleaned by the pickling bath shown or may be otherwise cleaned before coming to the furnace.

A similar pair of rolls indicated at **17** and **18** is located at the discharge end of the tunnel or hood, the strip being passed between the same before it leaves the furnace. These rolls are also preferably hollow and adapted to have a fluid passed therethrough. For the purpose of recuperation, the two pairs of rolls may be connected together by the pipes **19** and **20**, the pipe **19** connecting the rolls **16** and **17** and the pipe **20** connecting the rolls **15** and **18**.

The rolls **15** and **16** are connected at one end by a pipe **21** and the rolls **17** and **18** are similarly connected by a pipe **22**. A pump or the like as indicated at **23** may be located in one of the pipes **19** or **20** for causing a continuous circulation of water or other fluid through the rolls **15**, **16**, **17** and **18** whereby heat absorbed from the strip by the rolls **17** and **18** is returned to the rolls **15** and **16** to assist in the preheating of the strip.

At the juncture of the heating chamber and initial cooling chamber is located a roll **24** over which the strip is passed in its passage through the furnace. This roll may be formed of suitable heat resisting alloy and if desired may be hollow and continuously cooled by passing water or other cooling fluid therethrough, as by the pipe **24b**. In such latter case the roll may be of copper or similar material and of high heat and electrical conductive capacity.

This roll is a contact roll for passing electric current through the strip and is located in one

side of an electric circuit as indicated by the wire 25. As will be later explained, the other contact may be made by the strip before it enters the furnace, preferably by means of an aqueous bath.

For the purpose of controlling the cooling of the strip, a second water cooled roll 26 cooled by the pipe 26a may be spaced from the roll 24 and located slightly below the normal path of the strip through the furnace and a vertically adjustable water cooled roll 27 cooled by the pipe 27a may be normally located above and out of contact with the strip and adapted to be moved downward to the extreme position shown in broken lines in Fig. 1, causing considerable portions of the surfaces of the rolls 24, 26 and 27 to be contacted by the strip as shown in broken lines, in order to more rapidly cool the strip at this point. It will be understood that by vertically adjusting the roll 27 at points between the two extremes shown in the drawing any desired amount of cooling effect may be obtained at this point, as in some heat treatments of the strip it is desirable to cool from a high point to a somewhat lower temperature at a rapid rate to prevent grain growth, and then in order to maintain high ductility to cool more slowly to a lower temperature before the strip leaves the furnace.

The roll 27 may be vertically adjusted by any suitable means, such as the screw 27b connected to the bearings of the roll and provided with the nut 27c adapted to be rotated by any usual and well known means to raise and lower the screw and with it the roll 27.

Any suitable gas, which if desired may be an inert, nonoxidizing or reducing gas, may be continuously circulated through the furnace in the opposite direction to the movement of the strip as by the pipe 28, which may be provided with a fan 29 or the like for continuously withdrawing the gas from the charging end of the furnace and discharging it into the discharge end of the furnace. A dehydrator or gas purifier 28a may be inserted in the pipe line 28 to remove oxidizable constituents from the gas.

A tank 30 is located at a point spaced in front of the entrance end to the furnace for containing an aqueous bath which may be in the form of a pickling solution, through which the strip is passed before entering the furnace, the strip passing over and under the rolls 31 which convey it through and out of the bath.

An electrode 32 is immersed in the bath and preferably provided at its lower end with a flat conductor plate 33 spaced slightly above the path of the strip through the bath. This electrode is connected to the other side of the circuit as by the wire 34b which, like the wire 25, leads to a transformer 35.

After passing through the aqueous bath, the strip may pass through a washing tank 36 wherein spray nozzles 37 may be provided for washing the pickling solution or other solution from the aqueous bath off the strip which then passes through wipers 38, removing the majority of the moisture therefrom, any remaining moisture being dried between this point and the entrance to the furnace by the heat developed in the strip by resistance of the electric current between the contacts 32 and 27.

For the purpose of controlling the power input to the strip by the temperature of the strip without interrupting the circuit through the strip, the electrical circuit shown in Fig. 1 may be provided. The high tension wires 40 and 41 lead through the oil switch 42 to a regulator or controller indicated generally at 43, which may be of the type shown in P. M. Nagy Patent No. 1,697,401, issued January 1, 1929, this regulator or controller being connected as by the wires 44 and 45 with the transformer 35. A reversing motor 46 is provided for operating the regulator or controller 43.

A pyrometer couple 47 is extended into the heating chamber of the furnace adjacent to the strip at the point immediately before it passes over the contact roll 24 and is connected by the wires 48 with a contacting pyrometer 49 of any usual and well known construction which is arranged to alternately operate the relays 50 and 51. This contacting pyrometer is operated by the auxiliary circuit indicated at 52 which is also arranged to operate the reversing motor 46 through the armatures 53 and 54 respectively of the relays 50 and 51.

With this construction, the controller or regulator 43 is operated to produce the required power input from the transformer in order to maintain the desired temperature in the strip through the contacts 32 and 24, being controlled directly by the temperature of the strip through the pyrometer couple 47 without at any time interrupting the circuit through the strip.

In the operation of the furnace shown in Fig. 1, the strip is continuously passed through the aqueous bath in the tank 30, then washed and dried and heated up to the desired temperature as it passes through the heating chamber 11 of the furnace, being rapidly cooled below a critical temperature by the cooling effect of the roll 24 and if desired, the rolls 26 and 27, and then slowly cooled below the oxidizing temperature before it passes out of the final cooling chamber 13.

In Fig. 2 is shown an adaptation of the invention to a metal coating furnace for coating continuous strips of metal. In this form of the invention, the aqueous bath with electrode therein, the washing tank, resistance drying space, etc. may be of the same construction as previously described and illustrated in Fig. 1 and these parts are all indicated by the same reference characters as in Fig. 1. The furnace comprises a single elongated hood or tunnel 10a having the heating chamber 11a therein, the strip S' being passed entirely through the same and over the contact roll 24a connected to the circuit by the wire 25 in the same manner as shown and described in Fig. 1. This roll may be water cooled as by the pipe 24c, its area of contact being such as to cool the strip to the temperature desired in the strip as it enters the coating pot.

The roll 24a is located in the cooling chamber 12a which is preferably provided with the depending portion 12b extended beneath the level of the metal bath 56 in the tank 57, the strip passing under the roller 58 in said tank and then upward and away from the furnace as over the roller 59. The temperature of the strip as it enters the molten metal bath may, if desired, be sufficiently high to maintain the bath molten without the use of extraneous heat.

I claim:

1. A continuous strip furnace including an elongated heating chamber, means for maintaining a nonoxidizing atmosphere in the heating chamber, means for passing a metal strip through the furnace, an aqueous electric contact spaced from the entrance end of the furnace, and a contact roll in circuit with said electric contact, within the heating chamber adjacent to the discharge end thereof, means for cooling

said contact roll and a roll adjustable relative to said contact roll for varying the area of the strip contacting said contact roll whereby the strip is heated by electric resistance and then rapidly cooled as it passes through the furnace.

2. A continuous strip furnace including an elongated heating chamber, means for maintaining a nonoxidizing atmosphere in the heating chamber, an aqueous bath comprising a pickling solution outside of the entrance end of the furnace, a contact roll within the heating chamber adjacent to the discharge end thereof, an electrode in the aqueous bath, an electric circuit connected to said electrode in the aqueous bath and to said contact roll, and means for passing a metal strip through said aqueous bath but not in contact with said electrode and then through the heating chamber and over said contact roll whereby the strip is heated by resistance as it passes through the furnace.

3. A continuous strip furnace including an elongated heating chamber, means for maintaining a nonoxidizing atmosphere in the heating chamber, an aqueous bath outside of the entrance end of the furnace, a contact roll within the heating chamber adjacent to the discharge end thereof, means for cooling said contact roll, an electrode within said aqueous bath, an electric circuit connected to the electrode in said aqueous bath and to said contact roll, and means for passing a metal strip through said aqueous bath but not in contact with said electrode and then through the heating chamber and over said contact roll and means for varying the area of the strip contacting said contact roll whereby the strip is heated by resistance and then rapidly cooled as it passes through the furnace.

4. A continuous strip furnace including an elongated heating chamber, means for maintaining a nonoxidizing atmosphere in the heating chamber, an aqueous bath outside of the entrance end of the furnace, a contact roll within the heating chamber adjacent to the discharge end thereof, means for cooling said contact roll, an electric circuit connected to said aqueous bath and to said contact roll, and means for passing a metal strip through said aqueous bath and then through the heating chamber and over said contact roll whereby the strip is heated by resistance and then rapidly cooled as it passes through the furnace, and an adjustable water cooled roll movable relative to and cooperating with said contact roll for varying the area of the strip contacting said contact roll controlling the amount of cooling of the strip.

5. A continuous strip furnace including an elongated heating chamber, means for maintaining a nonoxidizing atmosphere in said heating chamber, an aqueous contact bath comprising a pickle solution spaced from the entrance end of the heating chamber, a resistance drying space between the aqueous bath and the heating chamber, washing means between the pickle solution and the drying space, a contact roll within the discharge end of the heating chamber, an electric circuit connected at opposite sides to the aqueous contact bath and the contact roll, and means for passing a metal strip through the aqueous contact bath, washing means, drying space and heating chamber and over said contact roll.

6. A continuous strip furnace including an elongated heating chamber, means for maintaining a nonoxidizing atmosphere in said heating chamber, an aqueous contact bath comprising a pickle solution spaced from the entrance end of the heating chamber, a resistance drying space between the aqueous bath and the heating chamber, a washing bath between the aqueous bath and the drying space, a contact roll within the discharge end of the heating chamber, an electric circuit connected at opposite sides to the aqueous contact bath and the contact roll, and means for passing a metal strip through the aqueous contact bath, washing bath, drying space and heating chamber and over said contact roll.

7. A continuous strip furnace including an elongated heating chamber, an electric contact near the entrance end of the chamber, an electric contact roll at the discharge end of the chamber, a fluid cooled roll spaced from the concontact roll, an adjustable roll spaced from the fluid cooled roll, an electric circuit connected to said electric contact and to said contact roll, means for passing a metal strip through the furnace in contact with said electric contact and said contact roll, and means for moving said adjustable roll for varying the area of the strip contacting said cooled roll for controlling the amount of cooling of the strip.

8. A continuous strip furnace including an elongated heating chamber, an electric contact near the entrance end of the chamber, an electric contact roll at the discharge end of the chamber, a fluid cooled roll spaced from the contact roll, an adjustable cooled roll spaced from the fluid cooled roll, an electric circuit connected to said electric contact and to said contact roll, means for passing a metal strip through the furnace in contact with said electric contact and said contact roll, and means for moving said adjustable roll for varying the area of the strip contacting said cooled rolls for controlling the amount of cooling of the strip.

9. A continuous strip furnace including an elongated heating chamber, an electric contact near the entrance end of the chamber, an electric contact fluid cooled roll at the discharge end of the chamber, a fluid cooled roll spaced from the contact roll, an adjustable roll spaced from the fluid cooled roll, an electric circuit connected to said electric contact and to said contact roll, means for passing a metal strip through the furnace in contact with said electric contact and said contact roll, and means for moving said adjustable roll for varying the area of the strip contacting said rolls for controlling the amount of cooling of the strip.

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