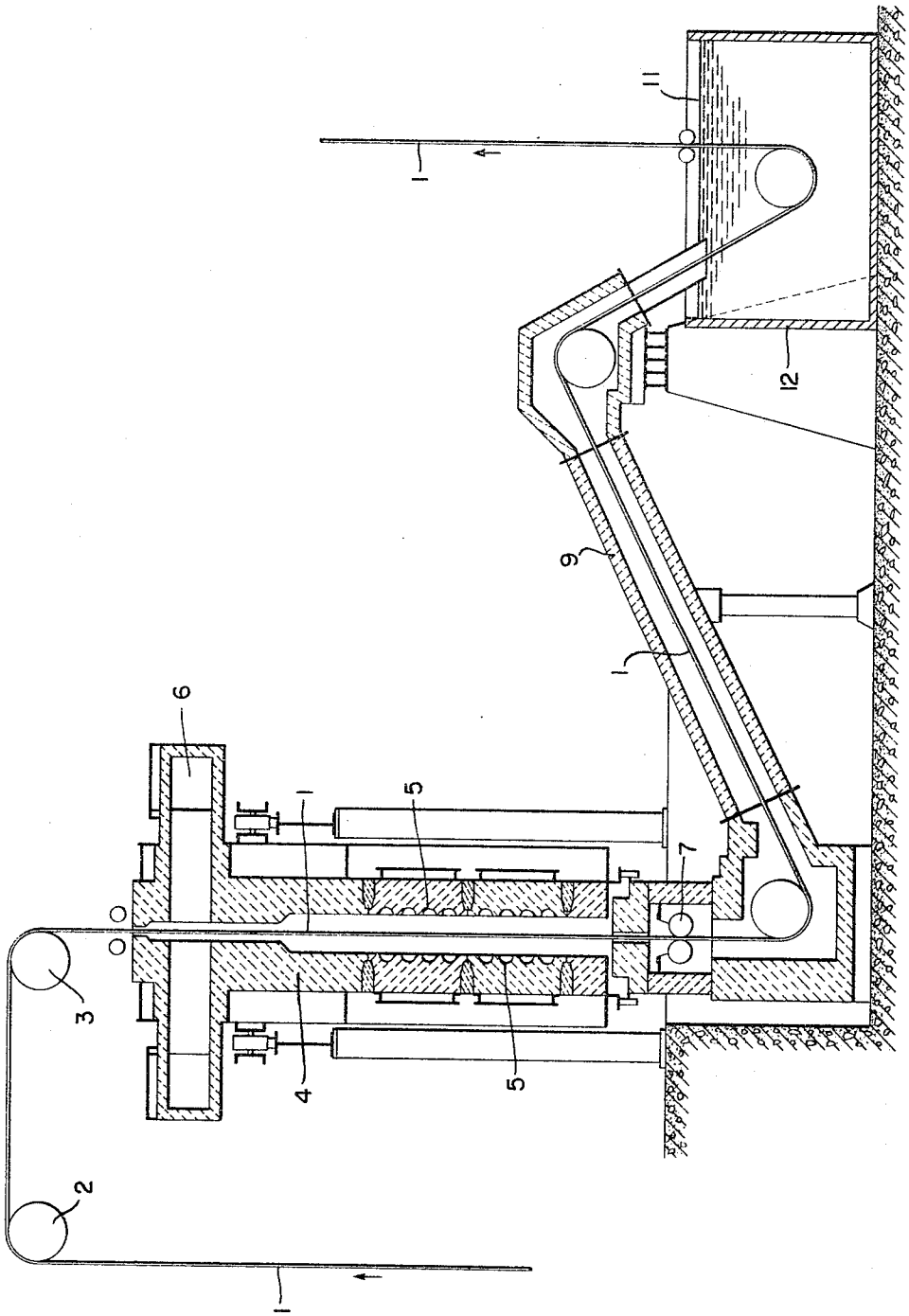
May 16, 1967 C. A. TURNER, JR 3,320,085

GALVANIZING

Filed March 19, 1965



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United States Patent Office 3,320,085
Patented May 16, 1967

3,320,085
GALVANIZING

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Filed Mar. 19, 1965, Ser. No. 441,286
9 Claims. (Cl. 117—51)

This application is a continuation-in-part of application Ser. No. 196,590, filed May 22, 1962, and now abandoned.

The present invention relates to galvanizing, and more particularly to a method of galvanizing carbon steel strip, although it can be used for galvanizing sheets, pipes, wire and other objects.

In the galvanizing of steel, the development of a tightly adherent zinc coating depends upon the strip of material entering the zinc bath, with a surface which is entirely free of oxide and dirt. Generally, continuous galvanizing lines incorporate washing and pickling of varying effectiveness. Following pickling, a water rinse and air drying are applied to the strip. The surface of the strip entering the furnace has on it an oxide film, from the drying, that is not necessarily observable to the eye, and some mild degree of surface contamination which results from prior processing, but is not eliminated by the in-line washing and pickling.

This slight contamination on the surface of the strip must be removed prior to the time that the strip is moved into the galvanizing bath.

In accordance with the present invention, the film is removed by what may be called gas fluxing as the strip is being heated. After the strip is heated, it is moved directly from the furnace, through a chute under a protective atmosphere, into the coating bath. No surface reactions take place in passage through this chute.

The strip to be coated must be cleaned, after it has been rolled or after rolled and batch annealed, before it is heated. This cleaning usually includes washing and pickling, followed by a water rinse. Such treatment produces a surface that is free of mill scale and rolling oil. There is still a thin coating of oxide on the strip surface, however, that, while it is substantially invisible to the eye, must be removed prior to the time the strip is coated in order to obtain a good bond between the strip and the coating metal.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, however, its advantages and specific objects attained with its use, reference should be had to the accompanying drawing and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

The single figure of drawing shows diagrammatically apparatus for processing the strip according to the invention.

The strip that is being treated can be a batch annealed, soft strip that has been surface cleaned or it can be a hard strip coming directly from a tandem mill. If the strip has been previously annealed and cleaned it will have a thin, almost invisible, oxide coat that must be removed prior to coating. If the strip is hard it will be free from scale, but will have an oil coat, and perhaps a slight oxide coating, both of which must be removed prior to coating. In either case, strip **1** is supplied over guide rollers **2** and **3** to travel downwardly in a vertical path through furnace **4**. The furnace, preferably is of the type shown in Bloom Patent 2,869,846, and is provided with radiant-cup type burners **5** which face the strip and fire directly into the furnace chamber. Products of combustion rise in the chamber and are exhausted through ducts **6** at the upper end of the furnace.

The strip is heated to a temperature that varies depending upon the result to be obtained, such as whether hard strip is being annealed or preheated without anneal, or whether prior annealed strip is being preheated only. In the latter case, which will be used as an example, the limits of heating are between 400° F. and 1050° F. If strip is heated above the upper limit, the benefits obtained by prior skin passing through a temper mill, as is usual, would be voided. In practice, the limits are usually between 800° F. and 1000° F. This is a more practical lower limit, since it minimizes the amount of external heat that is supplied to the galvanizing pot to maintain a desired bath temperature that is usually 850° F.

The furnace through which the strip travels is maintained at a minimum critical temperature, and the fuel-air ratio is controlled to provide the necessary reducing character of the gases (products of combustion) for effecting final strip clean-up. The fuel-air ratio of the furnace is regulated to provide a slight excess of fuel so that there is no free oxygen in the furnace atmosphere, and so that there are from 3% to 6% combustibles in the form of carbon monoxide and hydrogen. Gases of this analysis are oxidizing to steel when the gas and steel temperatures are in equilibrium. It has been found, however, when the furnace gases are at 2400° F. and over, to steel. Under these conditions, no improvement in the reducing potential of the gases results by employing a richer gas-air mixture. It is necessary, however, to maintain a positive pressure within the furnace to prevent infiltration of air.

With the furnace gases controlled as set forth above, the extent of removing oxide from the strip surface will depend upon the time that the strip is in the furnace and the temperature to which it is heated, with increasing temperature accelerating the cleaning or "gas fluxing" as it can be called. In any event the hot furnace gases will vaporize any oil on the strip, with the vapor leaving the furnace with the exhaust gases.

As noted above, a furnace atmosphere with at least 3% combustibles at 2400° F. is reducing to steel up to 1700° F., or a temperature difference of at least 700° F. If the furnace temperature is raised to 2800° F., steel will be reduced up to a temperature of 2300° F. or a temperature difference of 500° F. When the furnace temperature is less than 2400° F., this cleaning or gas fluxing does not take place, regardless of the steel temperature. If part of a given strip treatment requires that the strip be annealed, it can readily be heated to annealing temperature within the limits given above. The steel need be kept in the furnace only long enough for it to be heated to the desired temperature, which is ordinarily in the neighborhood of a few seconds, and suffices to effect the clean-up. The speed of the strip will be regulated primarily to provide this temperature. The higher the final strip temperature and the thicker its gauge, the longer it must remain in a furnace of a given temperature. This can be determined empirically.

When the strip leaves the furnace, it has a clean surface suitable for producing an adherent coating that must be protected. To this end, upon leaving the furnace, the strip passes between a pair of seal rolls **7** to and through a delivery duct **9** that is filled with a protecting atmosphere which can be neutral or reducing. The delivery end of this duct is below the level **11** of the molten zinc in pot **12**. Suitable guide rolls are provided to guide the strip from the furnace through the duct and pot. Duct **9** is preferably insulated and may have conventional provisions for heating or cooling so that the strip passing through it will be brought to the desired coating temperature.

If the coating metal is zinc, the bath will be kept at a temperature of about 850° F. Thus, the temperature to which the strip is heated will have an effect on the

requirements for maintaining the required molten bath temperature. If the strip is heated to 400° F., for example, as may be desirable with some types of steel, it will have a cooling effect on the zinc. Therefore, supplemental heat sufficient to make up for heat loss to the strip, for radiation losses and to melt additional zinc must be added to the strip as it passes through duct 9 or to the zinc pot. If the strip is heated to 1000° F., for example, it must be cooled to approximately 900° F. while it is passing through the protective atmosphere in duct 9 between the furnace 4 and pot 12 containing the coating bath. Ordinarily, pre-annealed strip would not be heated to this temperature, except to provide additional cleaning in the furnace in those cases where pre-cleaning ahead of the furnace was insufficient.

Generally speaking, it is desirable to supply the strip to the coating bath at or slightly above the temperature of the bath. In this way, a minimum amount of heat is needed to keep the bath at its optimum temperature.

Therefore, in practicing the invention with strip steel that has been batch annealed to a soft condition, the strip is heated according to the following procedures, and will depend somewhat upon how the strip was treated prior to annealing. If the strip was washed (oil removal) between rolling and batch annealing, it can be moved directly from the annealing furnace to the strip heating furnace 4. If, however, the strip is oil covered, or has been stored long enough to become rusty on the surface, then degreasing, pickling and washing will be required prior to heating for galvanizing. In either event, the final thin oxide coating on the strip is removed in the continuous heating furnace 4.

The thus cleaned strip, having only an extremely thin oxide coating on its surface, is moved through strip heating furnace 4 that has its atmosphere of products of combustion maintained at a temperature of at least 2400° F., and which has no free oxygen and at least 3% combustibles. For reasons of economy and maintaining a high temperature, it is preferred to keep the combustibles in the furnace atmosphere below 6%.

The speed of the strip through the furnace is such that its temperature is raised to between 400° F. and not above 1050° F. Normally, the strip will be heated to within 100° F. of the temperature of the coating metal, which for zinc would be about 850° F., or a little higher. The furnace atmosphere will be reducing to the steel strip within this temperature range. Consequently, the strip surface will be cleaned and prepared to receive the coating.

When the strip is heated, it is moved directly from the furnace to the coating bath or galvanizing pot 12 through duct 9 which is filled with a protective atmosphere. Whether or not the strip must be cooled while in duct 9 between the furnace and the coating bath will depend upon the temperature to which the strip was heated. In any event, the strip should not be more than about 100° above the temperature of the coating metal when it enters the coating bath.

While the process is primarily intended for galvanizing, and has been so described, it will be obvious that it can be used for the coating of steel with other metals such as aluminum. When this type of coating is performed, the strip will be heated to a temperature within the range of 1250° F. to 1300° F., since this is the temperature at which an aluminum coating bath is maintained. As noted above, the furnace atmosphere is still reducing to the steel at these temperatures, so the strip surface will be cleaned.

From the above description, it will be seen that I have provided a process by which a continuous length of steel can be prepared for coating, and coated with a minimum of preliminary treatment prior to the time the steel is introduced into the furnace for heating.

While in accordance with the provisions of the statutes, I have illustrated and described the best form of embodiment of my invention now known to me, it will be apparent to those skilled in the art that changes may be made in the form of the apparatus disclosed without departing from the spirit and scope of the invention set forth in the appended claims, and that in some cases certain features of my invention may be used to advantage without a corresponding use of other features.

What is claimed is:

1. The method of coating an elongated length of steel having a slight oxide on its surface which comprises heating a furnace by direct combustion of fuel and air therein to a temperature at least 2400° F. and with an atmosphere of gaseous products of combustion having no free oxygen and at least 3% combustibles, and providing a coating bath to molten zinc maintained at coating temperature, moving the length of steel that is free of scale and grease or oil into and through the products of combustion in the furnace, keeping the length of steel in the furnace long enough to heat it to a temperature below that at which it will be oxidized in said products of combustion so that when it reaches the bath it will be within 100° F. of the temperature of the bath, the furnace removing any oxide from the surface of the steel, and moving the steel through a protective atmosphere from the furnace into the coating bath.

2. The method of galvanizing a strip of steel which comprises moving a strip continuously through a furnace and into a coating bath of zinc and surrounding the strip with a protective atmosphere as it is moving between the furnace and the bath, the furnace serving to clean the surface of the strip whereby a tight coating will be obtained, the furnace being maintained at a temperature of at least 2400° F. with a gaseous atmosphere of no free oxygen and between 3% and 6% combustibles by burning fuel and air therein and the strip being heated directly in products of combustion from said burning to a temperature below that which it will be oxidized in said products of combustion, the strip temperature being controlled so that when it enters the bath it will be at a temperature of not more than 100° F. above the temperature of the coating bath.

3. The method of claim 2 in which the coating bath is maintained at about 850° F., and in which the steel is heated to a temperature between 850° F. and 950° F.

4. The method of coating a continuous length of steel with zinc which comprises moving steel with a thin oxide coating continuously through a furnace heated directly by the combustion of fuel and air and having a temperature of at least 2400° F. and an atmosphere of gaseous hot products of combustion having no free oxygen and at least 3% combustibles, keeping the steel in the furnace long enough to heat it to 400° F. and not over 1050° F., and moving the steel from the furnace through a protective atmosphere into a coating bath of the zinc.

5. The method of galvanizing strip steel which comprises moving the strip having a light oxide coating on its surface continuously through a furnace heated by direct combustion of fuel and air to a temperature of at least 2400° F. and having an atmosphere of gaseous products of combustion with no free oxygen and at least 3% combustibles, heating the strip in said furnace to a temperature from that of the coating bath to not more than about 100° F. above that of the coating bath, moving the strip from the furnace through a protective atmosphere into a coating bath of zinc maintained at a temperature of about 850° F.

6. The method of galvanizing steel strip which comprises supplying strip clean except for a thin oxide coating, moving the strip continuously through a furnace directly heated by burning fuel and air therein and into a zinc bath maintained at a temperature of about 850° F., keeping the furnace at a temperature of at least 2400° F. and with an atmosphere of gaseous products of combustion having no free oxygen and at least 3% combustibles, moving the strip through the furnace and its atmosphere

at a speed so that it will be heated to a temperature when it reaches the zinc bath of between the temperature of the zinc bath and a temperature about 100° F. above that of the zinc bath, the furnace removing the oxide from the strip at that temperature, and maintaining the strip in an atmosphere to prevent surface oxidation between the time it leaves the furnace and the time it enters the zinc bath.

7. A method of continuously galvanizing strip steel which comprises moving the strip into a furnace heated directly by the direct combustion of fuel and air to a temperature at least 2400° F. and with an atmosphere of gaseous products of combustion having between 3% and 6% combustibles and no free oxygen in the furnace, keeping the strip in the furnace atmosphere until it reaches a temperature of no higher than 1000° F., moving the strip through a protective atmosphere from the furnace into a galvanizing bath, and cooling the strip to a temperature of not more than about 100° F. above the temperature of the bath as it is moving through the protective atmosphere.

8. The method of galvanizing cleaned and batch annealed steel strip which comprises moving the strip with only a normal light oxide coating on its surface into a furnace heated by direct combustion of fuel and air and whose temperature is at least 2400° F. and whose atmosphere is gaseous products of combustion with no free oxygen and at least 3% combustibles in the form of carbon monoxide and hydrogen, moving the strip continuously through the furnace and in its atmosphere at a speed sufficient to bring its temperature up to not more than 1000° F., moving the strip continuously from the furnace into a coating bath of zinc at a temperature of about

850° F., and keeping a protective atmosphere around the strip as it is moving between the furnace and the coating bath, the furnace, at the temperature of the strip, serving to remove the oxide coating from the surface of the strip and prepare it to receive an adherent coating of zinc.

9. The method of removing an oxide coating from the surface of steel which comprises placing the steel in a furnace heated directly by combustion of fuel and air in the furnace and having a temperature of at least 2400° F. and with an atmosphere of gaseous products of combustion having no free oxygen and at least 3% combustibles consisting of carbon monoxide and hydrogen, and removing the steel from the furnace into a protective atmosphere before the steel has reached a temperature of 1700° F.

References Cited by the Examiner

UNITED STATES PATENTS

2,110,893	3/1938	Sendzimir	117—51 X
2,191,598	2/1940	Swartz et al.	117—51
2,197,622	4/1940	Sendzimir	117—51
2,401,374	6/1946	Sendzimir	117—51
2,459,161	1/1949	Harris et al.	117—51
2,625,495	1/1953	Cone et al.	134—15 X
3,010,844	11/1961	Klein et al.	117—114 X

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,320,085 May 16, 1967

Charles A. Turner, Jr.

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 25, after "over," insert -- and the steel is at about 1700° F. and lower, the gases are reducing --.

Signed and sealed this 28th day of November 1967.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents