United States Patent

[11] 3,633,650

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[31] **P 17 58 548.7**

[54] **METHOD OF MAKING AND TREATING A CONTINUOUSLY CAST METAL BODY**
4 Claims, 7 Drawing Figs.

[52] **U.S. Cl.** **164/76,** 117/129, 164/268
[51] **Int. Cl.** **B22d 11/12**
[50] **Field of Search** 164/4, 76, 82, 89, 268, 270, 273, 283; 117/107.1, 129

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ABSTRACT: A continuously cast body emerges from its mold in a hot, solid and relatively scale-free condition and passes immediately into a chamber prior to any substantial formation of scales on the body. In this chamber a powder of metals and metallic oxides which fuse at the temperature of the body are blown against it and melt. On cooling this melt hardens to form a thin glassy, enamellike coating which ruptures in the region of any surface flaws to indicate the presence of the latter and which protects the body from further scaling as it fully cools.

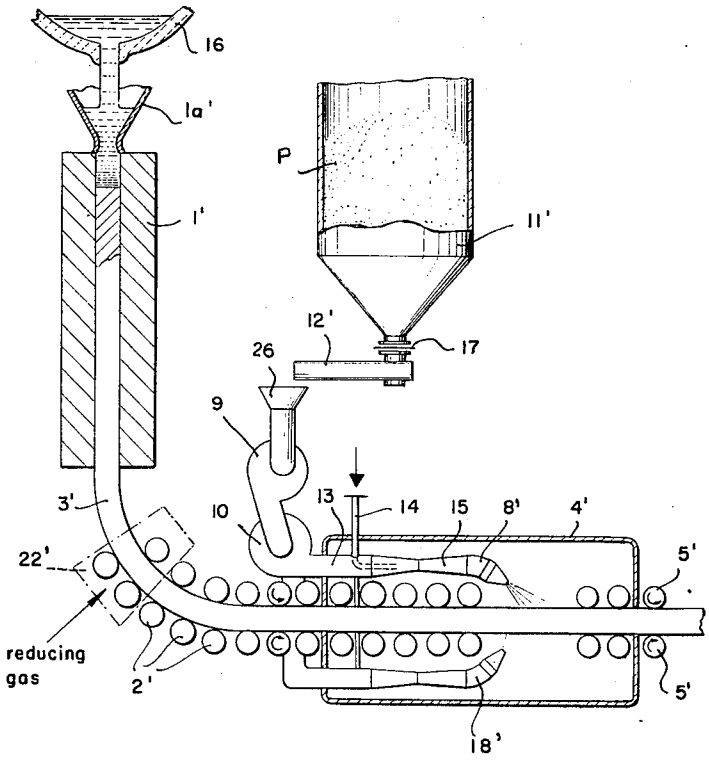
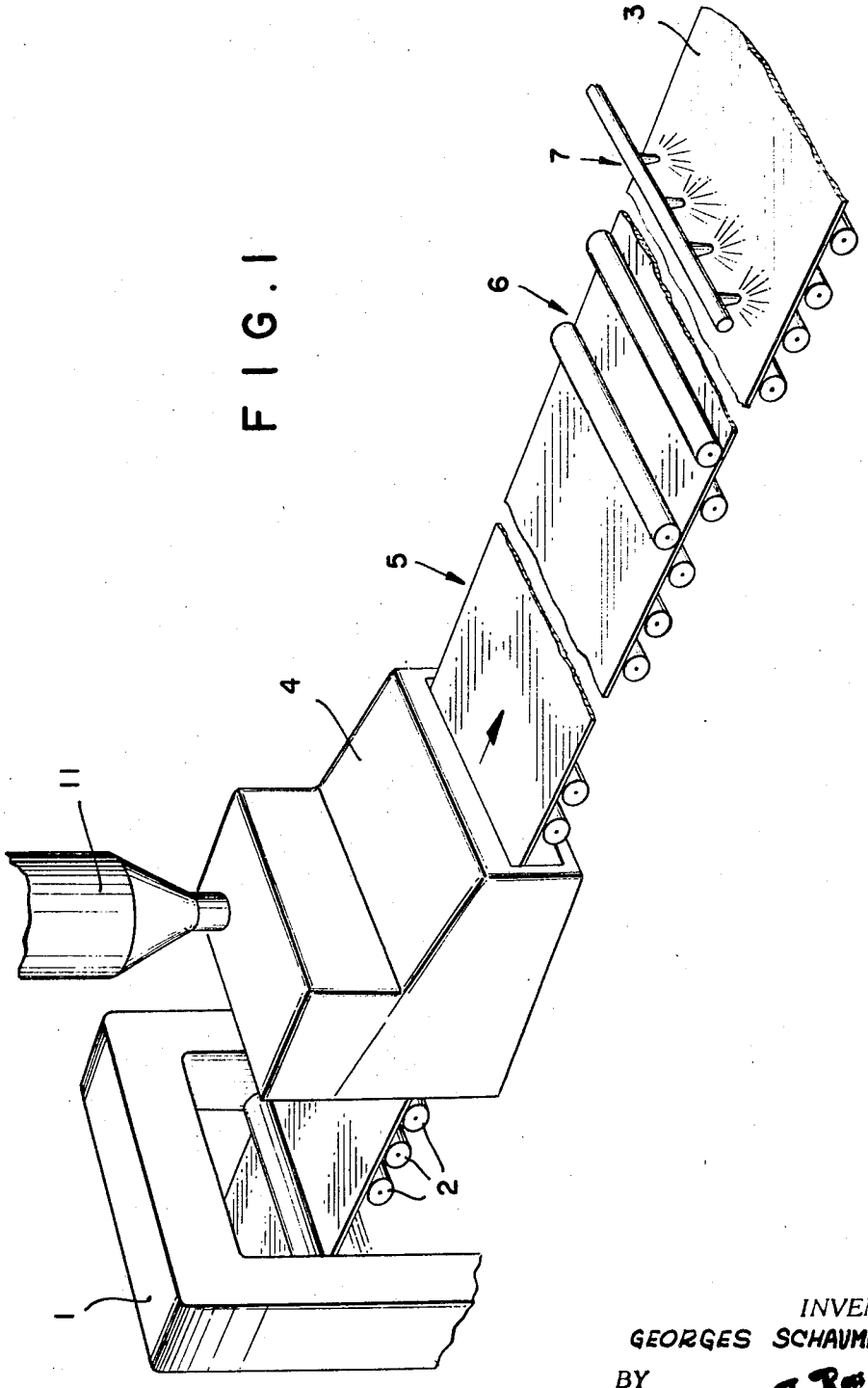


FIG. 1



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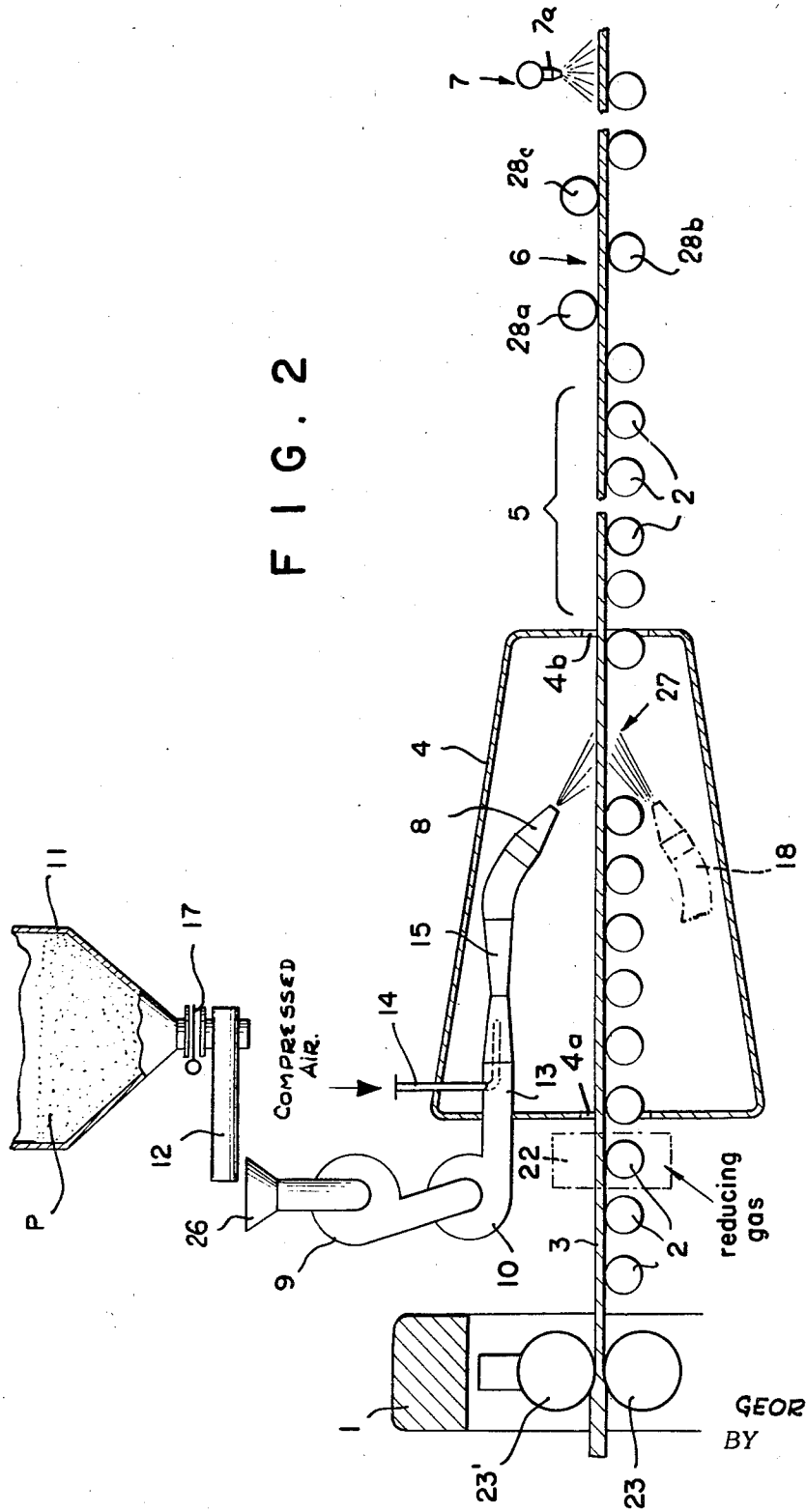

FIG. 2

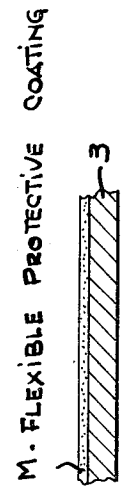

FIG. 7

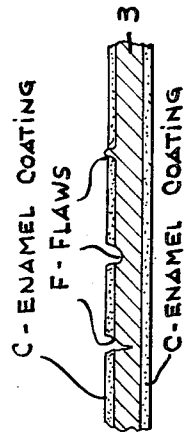

FIG. 6

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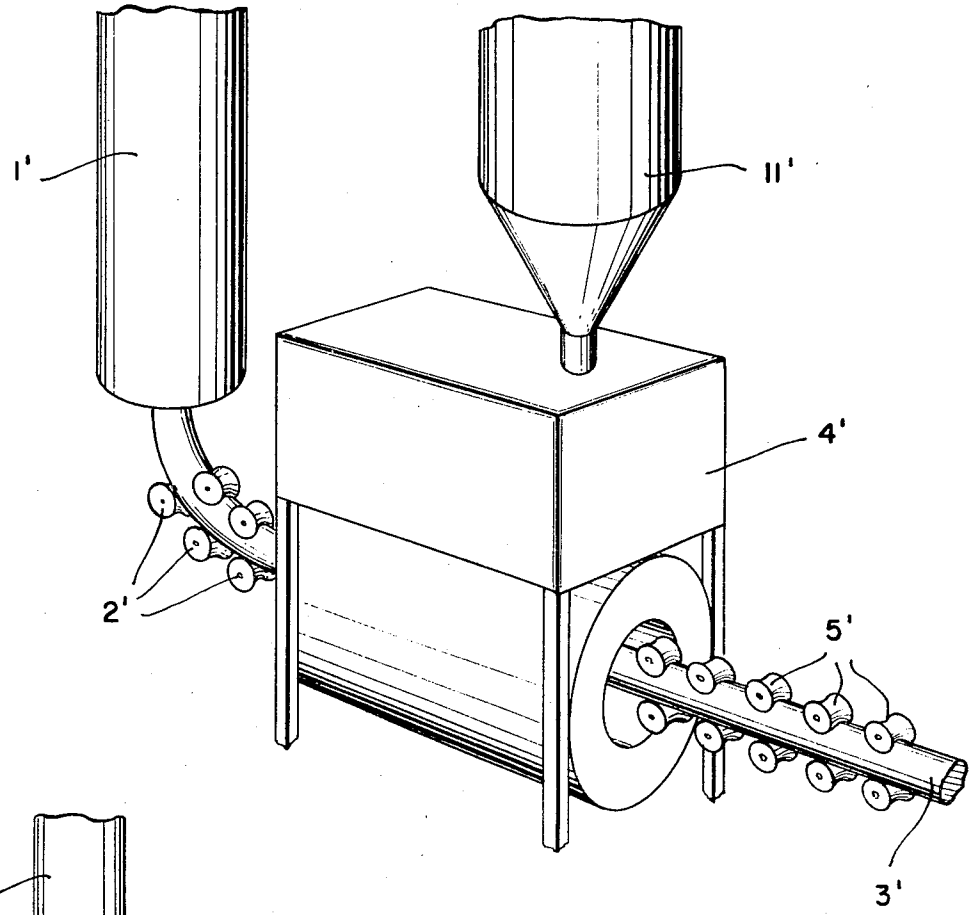
FIG. 3



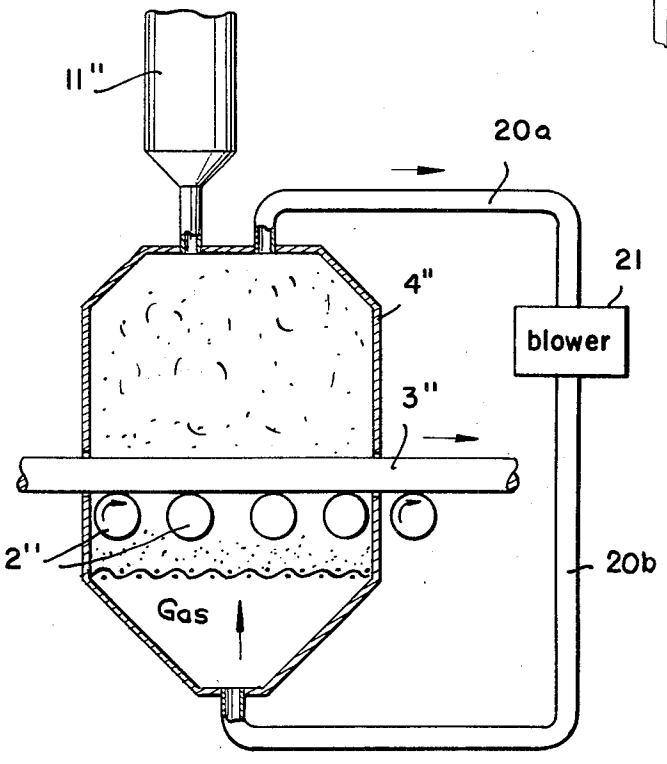


FIG. 5

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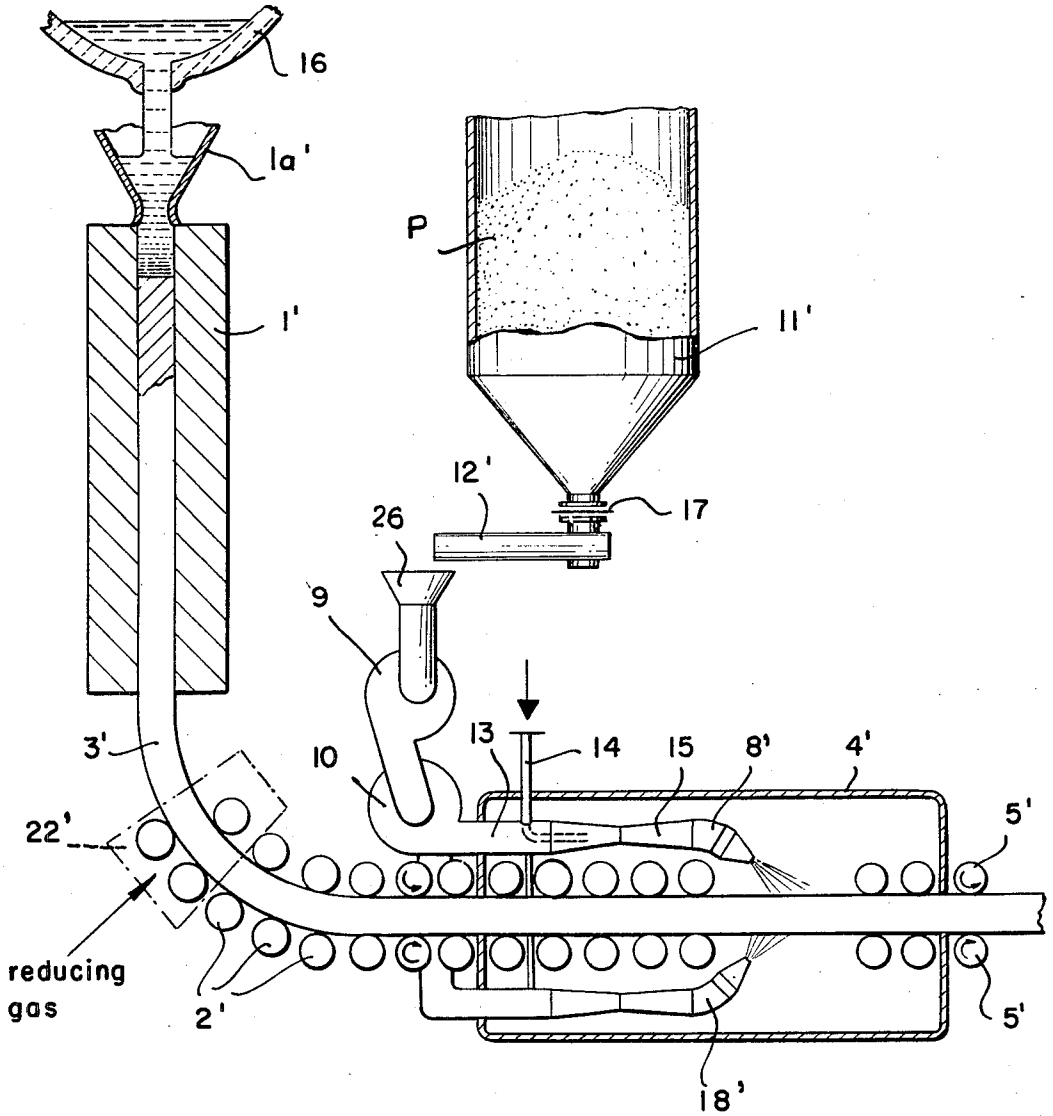

FIG. 4

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METHOD OF MAKING AND TREATING A CONTINUOUSLY CAST METAL BODY

FIELD OF THE INVENTION

The present invention relates to a method of making and treating a hot metal body and, more particularly, a method of making a scale-free body by continuous casting.

The invention also relates to a method of detecting surface defects or flaws in continuously cast bodies.

BACKGROUND OF THE INVENTION

Continuous casting has been proven to be an excellent method for forming continuous metal bodies such as rods and sheets. However, one of the major difficulties encountered in continuous casting is that the body emerges from its mold in a very hot condition and starts immediately to scale. This scaling, i.e., a slag or oxide encrustation, is detrimental to the surface appearance of metal, hides or obscures any surface flaws on the body, and, if allowed to remain during subsequent working of the body, can result in a reduction in structural strength or a weakening of the body. Indeed, major imperfections in a continuously cast metal body often defy detection due to the crusty scale formation on the body. Furthermore, the scale must be painstakingly removed by some such method as sandblasting or pickling which creates a bottleneck in production since it is very difficult to carry out these processes continuously moving workpiece.

OBJECTS OF THE INVENTION

It is, therefore, the general object of the present invention to provide an improved method of treating a metal body formed by continuous casting.

Another object is to provide an improved method of detecting surface flaws in a metal body of the character described.

More specifically, an object of the present invention is to provide such a method which overcomes the above-mentioned difficulties.

A further object is to provide an improved process for producing more or less continuous bodies and utilizing continuous casting as a step in this process.

SUMMARY OF THE INVENTION

The above objects are attained, in accordance with the principal features of the present invention, by a method of treating a metal body hot formed by continuous casting wherein the body passes directly (or after an intervening reducing treatment) into a treatment chamber as it emerges in a hot, solid and relatively scale-free condition from the mold. In this chamber, a powder consisting of a mixture of reducing agents to remove any slight scale and glass-forming substances which fuse at the temperature of the body is blown against the exterior of the body as it passes through this chamber. The powder fuses and, on cooling of the body, solidifies to form a glassy, enamel like coating which is so thin that it ruptures in the region of surface flaws, thereby pointing them up, and sealing the body from the ambient atmosphere to prevent any further scaling.

This treatment chamber, according to further specific features of the present invention, is fitted with at least one nozzle which is connected through at least one blower to a hopper containing the above-described powder. The nozzle is formed with a Venturi restriction and a small pipe opening longitudinally into the nozzle is connected to a source of gas under pressure to accelerate the powder and project it out of the nozzle against the body. An inert gas, a reducing gas, or simply air can be used as propellant.

The powder can be a mixture of oxides of silicon, magnesium, aluminum and iron along with metallic sodium, boron or potassium, or a compound of these metals. Zinc borate, according to a further feature of the present invention, has proven useful in the enamel layer in that the final product is effectively zinc coated upon removal of the coating.

In accordance with yet further features of the invention, the coated and cooled body can be stripped of its temporary glassy coating, for instance in a straightening station, and subsequently recoated for greater permanence by spraying with paint, lacquer, a synthetic-resin protective coating, or the like. Such a method is particularly advantageous in that the glassy coating is quite easy to remove from the body, i.e., is more easily removed than the customary scale, so that the body can be completely processed in one continuous operation.

Prior to the original coating, it is possible to subject the body to treatment with a reducing agent, such as hydrogen or methane, to remove any slight scale thereon. In this case, there is no need to admix reducing agents, such as powdered reducing metals, with the powder.

In an alternative embodiment the body, which can be a continuous rod, wire, sheet or the like, is simply passed through a fluidized bed of the above-described metal and metal oxide powders to coat it. In any case, the coating must be thin enough to rupture in the region of any flaws, or to allow the flaws to be seen through the coating, while being tough enough not to flake off immediately as the workpiece is transported.

Thus, a key feature of the present invention is the formation of a glasslike coating upon the surface of a hot-formed body while it is still in the heated condition and susceptible to scaling, of a relatively thin and brittle character upon cooling. This enamel layer, which may be composed of any conventional enameling composition, dispensed in the liquid or solid state and merely solidifiable on the body and/or fusible thereon utilizing the heat of the body, surprisingly is capable of providing a visible indication of surface flaws or defects in the body. While the mechanism of this system is not fully understood, it would appear that the enamel film ruptures, fractures or breaks in the presence of surface flaws, e.g. pits, striations, projections, contamination areas, cracking and similar defects, either as a consequence of thermal stress during cooling, or mechanical movement of various portions of the defect area, etc. or as a result of an inability to adhere effectively to these regions, thereby producing a fracture zone in the region of the defects. This marking or indication of the defects permits the defective material to be removed or otherwise monitored to ensure that the finished product will be free from the flaws. The enamel layer does not remain as tenaciously upon the body as would a slag layer or other scale-forming material, but rather can be broken away with ease as will be apparent hereinafter.

While reference has been made above to enamel and glass-like material as capable of fulfilling the requirements of the present invention, it may be noted that numerous enamel compositions which are capable of melting at a wide range of temperatures including the temperatures at which the metal (steel) body emerges from the hot-forming stage, are known and may be used in accordance with the present invention as long as the material is applied to the body with a viscosity sufficiently low to enable the liquid material to flow into a uniform thin film coating the body. This film, which may have a thickness of the order of microns, e.g. 5–10 microns, may either be applied in the form of a liquid coating or glass or may be applied in a powder stream, e.g. designed to fuse to flow along the surface at the temperature of the body, but in either case will be a glassy substance.

When powders are used, it is preferred to direct them against the body in high-velocity aerosol-type jets, the velocity being controlled by compressed air. At sufficiently high velocity, the powder effectively penetrates the surface skin of the metal, which can be assumed to be substantially free from scale, and is rapidly heated by its intimate contact with the metal to the melting point of the powder and thereabove, whereby the molten droplets coalesce to form a liquid glass film upon the surface of the metal. Preferably, this treatment is carried out in a tubular chamber enclosing the body and open at its ends to permit the body to pass through the chamber. The latter is provided with a configuration geometri-

cally similar to that of the body, i.e., a chamber of circular cross section when the body is a continuously cast rod of circular cross section.

As noted earlier, an important feature of this invention resides in the provision of reducing agents in the treatment process to eliminate any scale which may have been formed on the body prior to coating with the enamel layer. Thus, the body may be treated with a reducing gas or reducing agents, e.g. sodium, potassium and like reducing metals may be employed, the reduction products and the oxidized metal compounds resulting from the reducing reaction being incorporated in the subsequently formed enamel coating. In this respect, it may be noted that scale layers, when composed of the slag former present in metallurgical systems are of a glassy nature and are soluble in the glasslike enamel coating applied in accordance with the present invention.

In applying the powders, preferably in the form of a powder mixture of the character set forth above, it has been found to be advantageous to provide a tandem array of blowers, the first receiving a mixture of powders and air and constituting a loosening means whereby the powders are dispersed in the air stream to form a flowable mixture. In the second or downstream blower, the powder/air mixture is accelerated to a high velocity and propelled to a discharge nozzle trained upon the hot-metal surface. Between this nozzle and the second blower, there may be provided a Venturi injector to which compressed air is fed to regulate the velocity of the powder/air mixture directed against the workpiece surface.

While the invention is effective with hot-formed metals of any type, it has been found that hot-rolled products deriving from a rolling mill in which hot ingots or blooms are rolled in a heated state, and continuous casting arrangements offer the best sources of the bodies which are treated in accordance with this invention. Of course, the steps enumerated above apply whether the bodies are rolled or continuously cast, and either type of body may be subjected to the subsequent treatment as indicated earlier to form a final and more or less permanent coating therein.

DESCRIPTION OF THE DRAWING

The above and other objects, features and advantages will become more apparent from the following description, reference being made to the accompanying drawing, in which:

FIG. 1 is a perspective view of a rolling mill embodying the principles of the present invention;

FIG. 2 is a vertical section through the rolling mill of FIG. 1;

FIG. 3 is a perspective view of a continuous casting installation embodying the principles of the present invention;

FIG. 4 is a vertical section through the installation of FIG. 3;

FIG. 5 is a vertical section through another apparatus embodying the present invention; and

FIGS. 6 and 7 are sections through a metal body at two separate stages in its treatment according to the present invention.

SPECIFIC DESCRIPTION

As seen in FIGS. 1 and 2, a slab or sheet 3 is formed between two rolls 23 and 23' of a last rolling stage 1 of a rolling train. This slab 3 emerges from between these rolls 23 and 23' in a very hot, solid and relatively scale-free condition. It is transported by driven rollers 2 through a chamber 22 where it is subjected to the reduction effects of a reducing gas, e.g. hydrogen, carbon monoxide, methane or mixtures thereof, to remove any slight scale formations which might have come into being thereon.

The slab 3, still hot, then enters an inlet 4*a* of a treatment chamber 4. As it passes through this chamber 4 it is contacted on all its surfaces by a powder P which is a mixture of reducing metal and metal oxide particles that fuse on the surface and form a very hard, inflexible enamellike glassy coating (see FIG. 6). In addition, other substances (e.g. zinc) needed for the later surface treatment of this body can be added to this powder in the form of the material itself or as another substance (e.g. zinc borate) in which produces the desired coating or alloying substance in situ.

These powders are held in a hopper 11 which is closed by a vane 17 and connected through a conduit 12 to a funnel 26 feeding a first aerating blower 9 in turn connected to a second driving blower 10. A conduit 13 leading from this second blower 10 is formed with a Venturi restriction 15 just downstream from the end of a narrow pipe 14 into which compressed air is fed. Thence the aerosol particles P are expelled through a nozzle 8 onto the slab 3 all around the latter. Thus another nozzle 18 can be connected also to the blower 10 and the pipe 14 to cause the fine particles P to impinge against the underside of the slab 3 in a region 27 free of rollers 2.

After the treated slab 3 exits through an outlet opening 4*b* of the chamber 4 it passes along a region 5 where it cools and the coating becomes very hard. FIG. 6 shows the slab 3 with its hardened coatings C.

Further downstream the slab 3 passes through a straightening station 6 where three rollers 28*a–c* bend the slab 3 sufficiently to break free the coating C. Due to the regularity of this coating, it is easily removed. This coating is, however, very tight on the metal body 3, since the surface of the body 3 reacts to some extent with the wetted powders P to form the coating C.

Finally a coating station 7 having a plurality of nozzles 7*a* sprays a more flexible protective coating M, e.g. paint, upon the surface of the cooled slab 3. This coating M is shown in FIG. 7.

Because of the thinness of the coating C, any flaws, as shown at F in FIG. 6, will not be covered; the coating C will break in the region of these flaws F. Thus, an observer in the region 5 can clearly see them and mark the slab 3 in this region so that it can be later discarded.

In this manner, the flaws are easily recognized and there is no need to do a major descaling of the sheet 3, since any slight scale is removed by the gas in the chamber 22 or the oxides sprayed against it in the chamber 4 and, for the rest of the cooling time, the sheet 3 is covered by a very tight, nearly continuous glassy coating. Removal of this coating C has been found to be very simple once the sheet 3 is fully cooled and further scaling is no longer a problem.

FIGS. 3 and 4 shown an alternative embodiment of the present invention. Here, molten metal is poured from a ladle 16 into a funnel 1*a'* on top of a mold 1' of a continuous casting installation. A metal body in the form of a thick wire 3' leaves the base of this mold 1' and is bent through 90° by driven rollers 2 of hyperbolic profile and through a chamber 22' similar to the chamber 22 of FIGS. 1 and 2.

A boxlike chamber 4' is equipped with two nozzles 18' and 8' connected through a powder-aerating apparatus to a hopper 11' just as in FIGS 1 and 2, common reference numerals referring to common structure. This wire 3' is here coated according to the method and principles set out in connection with FIGS. 1 and 2.

As the wire 3' leaves the box 4', it is gripped between rollers 5'.

In this embodiment, the enamel coating is not stripped off the wire 3', since it serves to protect the wire during shipping and handling, and relatively easily removed when desired. This coating also serves to accentuate and make more visible flaws in the surface of the wire 3', as described above for FIGS. 1 and 2.

FIG. 5 shows a further embodiment of the invention having in this case a treatment chamber 4". Here a fluidized bed is formed around a continuous workpiece 3" riding on rollers 2". The workpiece 3" is very hot and relatively scale free. A blower 21 is having an output connected through a conduit 20*b* to the bottom of the chamber 4" and an input conduit 20*a* connected to the top of this chamber 4" serves to fluidize minute metallic and metallic oxide particles P fed into the chamber through a conduit 11*a*" connected to a hopper 11" above the chamber 4". In this way the workpiece 3" is very ef-

ficiently covered by the powder, so that it can move at high speeds through the chamber 4" and still be adequately coated.

SPECIFIC EXAMPLES

Example A

A steel body is hot formed and enters the treatment chamber at a temperature somewhat below its melting point. It is sprayed with a mixture of powders such that substantially equal parts of $Si0_2$, $A1_20_3$, Fe_20_3, Ca0, Mg0, Na, K, and B mixed with and carried by air strike the surface of the body. This mixture reduces the slight scale on the surface and fuses to form a glassy enamellike coating over the entire exterior of the body, the fused mixture flowing to cover all of its surface to a thickness on the order of say 5 to 10 microns. As the body cools, the enamel coating breaks in the region of any flaws on it.

Example B

A steel wire is formed by rolling and enters a treatment chamber as above. In this chamber it is sprayed with a powder whose prime constituent is zinc borate. The hard, enamellike coating is formed as above. Then the body is fed through a straightening apparatus which removes the coating and is found to be zinc coated in the sense that zinc is alloyed with surface zones of the metal body.

I claim:

1. In the continuous casting of a metal body wherein the body emerges from a casting stage in a solid, hot and relatively scale-free condition, the steps of progressively applying to the exterior of said body, as it emerges from said casting stage in its hot condition prior to substantial scale formation on said body, a glass-forming substance fusible at least at the temperature of said body to form a glassy coating thereon, said coating being applied sufficiently thinly to visually accent surface flaws on said body by rupturing in the region of such flaws; and cooling said coating to congeal it and effect selective rupturing of the coating in the region of such flaws.

2. The method defined in claim 1 wherein said coating is formed in part by interaction between said substance and said body.

3. The method defined in claim 1 wherein said substance consists at least partially of a reducing agent to remove any slight oxide formation on said body.

4. The method defined in claim 1 wherein said substance consists at least partially of a material desirable for later surface treatment of said body.

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