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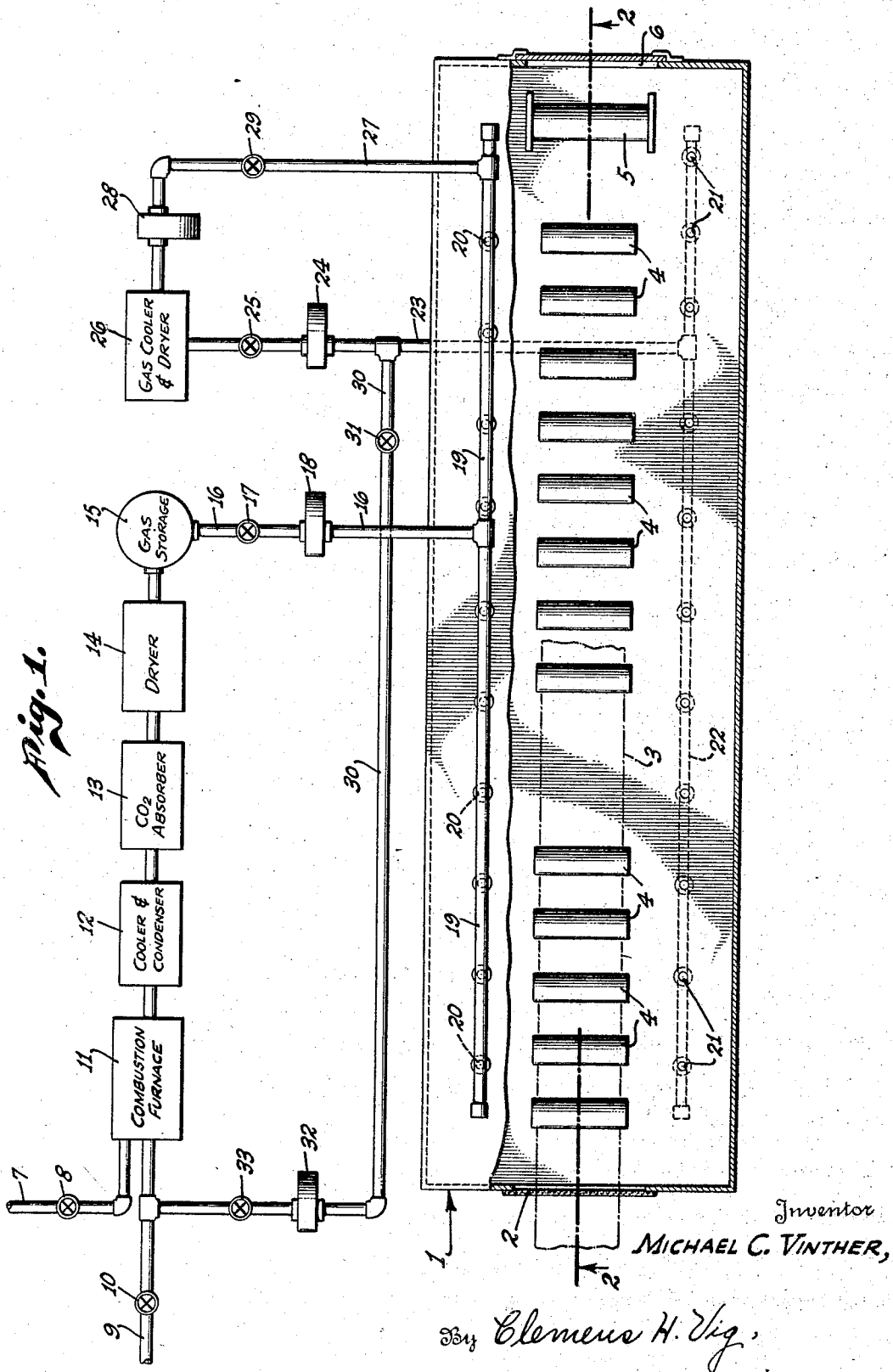
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PROCESS OF ROLLING STEEL IN INERT GAS ENCLOSURES

Filed April 21, 1941

2 Sheets-Sheet 1



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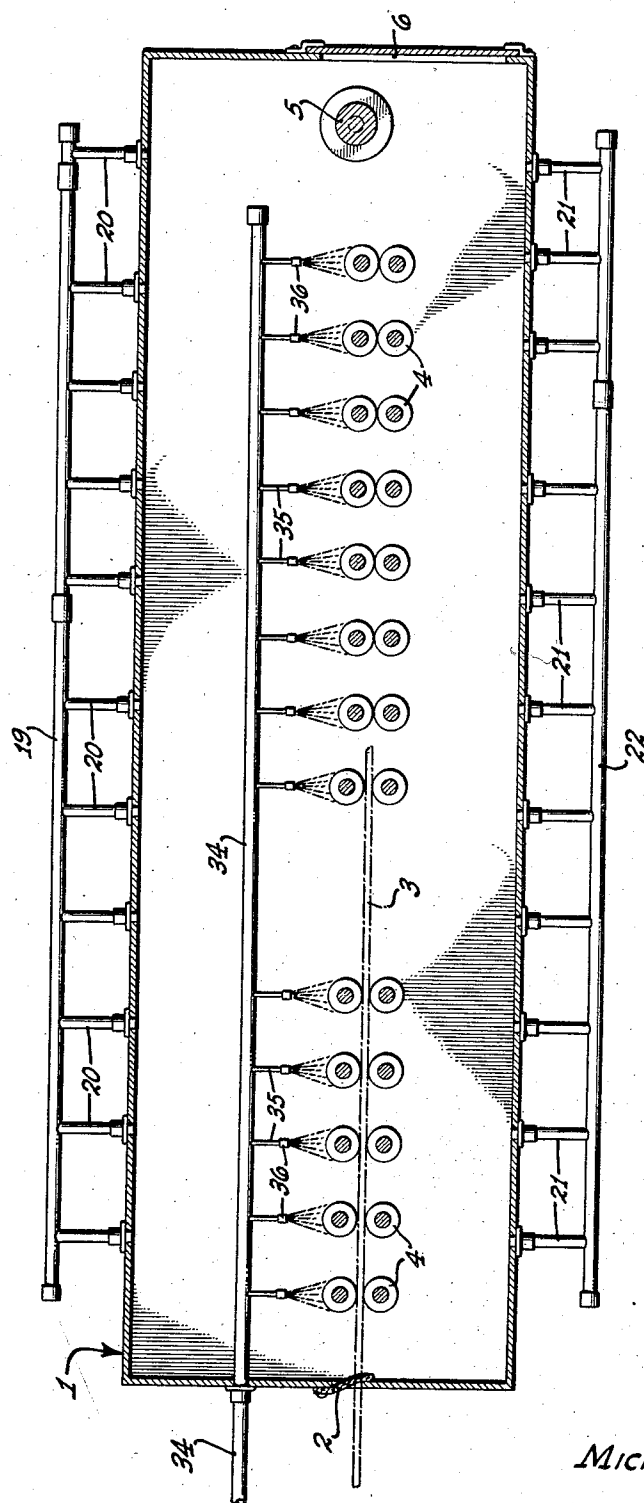


Fig. 2.

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PROCESS OF ROLLING STEEL IN INERT GAS ENCLOSURES

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20 Claims. (Cl. 80—60)

This invention relates to a process of rolling steel or iron, and it has particular relation to a process for rolling hot steel or iron in an inert gas enclosure, and may be used for hot rolling of other metals, such as copper and nickel and their alloys.

The main object of my invention is to keep the atmosphere surrounding the rolling mill in such a condition that it will not cause oxidation or scaling of the metal which is being rolled. Another object of my invention is to keep the atmosphere surrounding the mill sufficiently cool so that the operators of the mill can work in said atmosphere. A further object of my invention is to provide a process for circulating and treating the gas used in the mill enclosure so that the rolls of the mill can be cooled externally without causing oxidation of the metal being rolled, thus permitting the use of solid rolls in the mill. These and further objects of my invention will more fully appear from the following description, taken in connection with the accompanying drawings.

When steel or iron is formed into commercial form, it is usually done by rolling a large body of hot steel which has first been heated to a high temperature, sometimes as high as about 1100 degrees centigrade. If the rolling is performed in the ordinary atmosphere, which contains oxygen and traces of water vapor and carbon dioxide, there is a continuous oxidation of the hot surface of the steel, which causes a loss of steel as rust or scale and necessitates subsequent pickling or acid treatment of the steel in order to remove the scale. This scale formation is an especially costly waste when the surface area per ton of rolled steel is large, as in the case of sheet, strip, or wire rod.

The oxidation is caused mainly by oxygen in the air and to a lesser degree by moisture in the atmosphere. Carbon dioxide will also cause some oxidation if it is present in the atmosphere.

The present invention, by circulating and treating the atmosphere surrounding the mill, improves the process of rolling hot steel or other metal so that oxidation and scaling are partly or entirely eliminated during the rolling process.

The idea of hot rolling of steel in an inert atmosphere is not entirely new, as this has been proposed for rolling wire rods and also for rolling hot slabs into sheets. So far as I am aware, however, none of the proposed plans have ever been carried into successful operation, chiefly due to the fact that they used hollow rolls, which have

proved to be unsatisfactory because they lack strength and stiffness, and because the internal cooling of such rolls could not be regulated and controlled, and also because the mills had to be operated from outside the inert gas enclosure.

When rolling hot steel or other metal in an inert gas enclosure, there is the problem of cooling the enclosure, and also the problem of cooling the rolls, as there is a great deal of heat liberated from the hot metal and also from power converted into heat by the machinery.

It is extremely important to cool the rolls, for if they become too hot they will soften, lose strength and stiffness, and become distorted so that they will not roll the material into the exact shape desired. In the case of rolling sheet, then, it is often necessary to control the shape of the rolls by cooling the proper parts of the rolls. If, for instance, the middle of the roll becomes too hot, there will be irregular expansion of this part of the roll which will cause the rolled sheets to be too thin in the middle.

The prior art proposals for rolling hot steel in an inert atmosphere used hollow rolls, through which cooling water was passed in order to cool them. This had several disadvantages. The most serious disadvantage of hollow rolls is that they have far less strength and stiffness than solid rolls, so that less pressure can be applied during the rolling, and less rolling effect or reduction of the steel can be accomplished in each rolling, with the result that a larger number of rolls and roll stands would be required, thus increasing the cost of the rolling.

Furthermore, it is difficult to properly regulate the cooling of different parts of the hollow rolls by internal cooling. If a part of the roll, such as the middle, becomes worn more than the ends of the roll, then it is necessary to cool this part less in order that the added expansion will compensate for the worn part of the roll. But this was not accomplished by the hollow rolls, which had a fixed internal cooling channel, which made the cooling effect evenly distributed throughout the whole length of the roll.

The prior art proposals for rolling hot steel in an inert gas enclosure did not cool the gas or atmosphere used in the enclosure, with the result that the temperature would become so high that the operators of the mill could not stay in the enclosure and operate the machinery. Consequently, the machinery had to be operated from the outside, which is a disadvantage and rather impractical, since, so far as I am aware, no mill

has been operated without requiring some kind of manual work and attention.

The present invention overcomes the difficulties of cooling the rolls without making them hollow, and also provides a process for regulating the temperature of the inert gas or atmosphere in the enclosure.

In accordance with the present invention, the rolls are cooled externally by spraying water or other cooling liquid directly on the rolls. This spray water will be converted into steam by contact with the hot rolls, and if nothing further were done, it would contaminate the inert gas enclosure so that the atmosphere therein would no longer be inert, but in my process I remove the gas or atmosphere from the enclosure, dry it, and return it to the enclosure. This may be done continuously, and in any event, this circulation and drying of the gas or atmosphere is performed at such a rate that the moisture content of the gas is kept at such a low percentage that the gas or atmosphere remains substantially non-corrosive to the hot metal.

The water or other cooling liquid may be sprayed on the outside of the rolls in any suitable way. I may use fixed spray nozzles above the top roll, or spray nozzles on the side of the rolls, arranged so that the water falls on both the top and lower rolls. The spray nozzles may also be attached to a flexible hose, so the water can be directed against any desired part of the rolls. Steam may be used instead of water.

Instead of water spray or steam, I may use a spray of any other liquid which is vaporized by contact with the hot rolls and which is substantially inert in contact with the hot steel or iron, such as for instance trichlorethylene and tetrachlorethane. Since these liquids are of high cost, the vapors will be recovered for re-use by condensing in a cooler, or I may use any suitable absorber for recovery of the vapors. Liquid nitrogen may also be used to spray on the hot rolls, which will not only cool the rolls, but also supply inert gas for the mill enclosure.

In accordance with the present invention, the inert gas used in the enclosure is also cooled, thereby making it possible for the operators of the mill to work inside the enclosure. These operators may use hose masks or oxygen breathing apparatus for respiration.

The inert gas to be used in the mill enclosure may be produced by combustion of a fuel such as coke oven gas or natural gas, or I may use the flue gas from a boiler plant or furnace. The combustion gas or flue gas is first cooled to condense out most of the moisture and remove dust. The carbon dioxide is next removed, which may for example be done by absorption in a solution of alkali carbonate or an organic amine solution such as monoethanolamine. The remaining moisture may be removed by passing the gas through a layer of activated aluminum oxide, or by any other suitable means of air drying.

For example, by combustion of natural gas, we may obtain a hot combustion gas of the composition: 22% water vapor, 10% carbon dioxide and 0.5% carbon monoxide, the rest being nearly all nitrogen. By cooling to about 15 degrees centigrade, most of the moisture will condense. The carbon dioxide is next removed by absorption in monoethanolamine or alkali carbonate.

During the rolling process, the gas in the mill enclosure becomes hot and contaminated with moisture from spraying water on the rolls, so I remove the gas, which, for example, contains

3% water vapor and has attained a temperature of 35 degrees centigrade, and pass it through a cooler, which may be a spray of cold water, so that the gas is, for example, cooled down to 15 degrees centigrade and contains only 1½ volume percent of water vapor. This gas is returned to the inert gas enclosure.

If the gas in the mill enclosure contains gases which are slightly oxidizing, such as traces of oxygen and carbon dioxide and water vapor from the cooling water applied to spray cooling of the rolls, then I make a correction by adding a reducing gas such as hydrogen, carbon monoxide or gas which is a mixture of those gases, or a hydrocarbon gas such as methane.

For example, if the gas in the mill enclosure contains 3 volume per cent of water vapor and traces of carbon dioxide and oxygen, I add, for instance, 4 volume per cent of hydrogen, which will largely compensate for the oxidizing effect of the moisture.

The gas used in the mill enclosure may be made to contain sufficient hydrogen and carbon monoxide by using less than the theoretical amount of air for combustion in the combustion furnace, so that the hot flue gas contains nitrogen, carbon dioxide, water vapor, hydrogen, and carbon monoxide.

I may also use liquid nitrogen to cool the rolls. I spray the liquid nitrogen on the hot rolls, and the vaporizations of it provides cooling and at the same time the gas produced from the vaporization furnishes the inert gas, an atmosphere of nitrogen. In case the liquid nitrogen does not sufficiently cool the gas or atmosphere in the mill enclosure, the gas may be circulated to a cooler and then returned to the mill enclosure, but no drying of the gas will be necessary in this case because water is not used for cooling of the rolls.

In the accompanying drawings, I show one form of apparatus for carrying my process into effect, and in which—

Figure 1 is a diagrammatic plan view of a rolling mill enclosed in an inert gas enclosure, and apparatus for producing, treating, and circulating the inert gas, the top of the inert gas enclosure being partly broken away to reveal the internal construction; and

Figure 2 is a sectional view of the rolling mill and the inert gas enclosure, taken along the line 2—2 of Figure 1, and showing the water pipes and nozzles for spraying the rolls.

Referring to the drawings, 1 is an inert gas enclosure surrounding the entire rolling mill. It is a sufficiently gas-tight enclosure built of any suitable material, such as for instance welded sheet iron. 2 is an opening for bringing in the hot steel or other metal to be rolled. A suitable conveyor may extend through this opening, which may be provided with asbestos skirts to prevent any great leakage of inert gas. 3 is a billet of hot steel or iron which is being rolled into wire rod. 4 is the rolls for rolling the hot steel or iron. The rolls are placed in stands or housings and are provided with any suitable motors and drives, which are not shown. Neither do I show guides for leading the billet or rod being rolled.

5 is a coiler or reel for coiling or reeling the rolled steel, in this case a wire rod. There may be several reels or coilers, although the drawings show only one. 6 is the outlet where the rolled steel or metal is carried out of the enclosure. It may be simply an asbestos skirt, or it may be a double door gate. There may be any suitable

conveyor to carry the roller steel out of the inert gas enclosure 1.

7 is a gas pipe, provided with a suitable valve 8, for supplying a gas such as natural gas to the combustion furnace. 9 is a pipe for supplying air to the combustion furnace. This pipe is provided with a suitable valve 10. 11 is a combustion furnace for controlled combustion of gas. It may be provided with a catalyst to use air low in oxygen. 12 is a cooler for the combustion gas where most of the moisture formed during combustion is condensed out by cooling. 13 is a carbon dioxide absorber. It is a tower or agitator where the gas comes in thorough contact with a carbon dioxide absorbent such as alkali carbonate or a solution of organic amines. 14 is a drier, which may be a tower containing a drying medium, such as activated alumina. 15 is an inert gas storage.

Leading from the gas storage 15 is a pipe 16 provided with a valve 17 and a fan 18. This pipe 16 connects with a pipe 19, which latter pipe is situated over the top of the inert gas enclosure 1 and which is provided with several connecting pipes 20 leading into the top of the enclosure 1.

For removing the hot, wet, or contaminated gas from the mill enclosure 1, I provide several branch pipes 21, leading from the bottom of the inert gas enclosure 1 to a main pipe 22, which connects with pipe 23. This pipe 23 is provided with a fan 24 and a valve 25 and leads to the combined cooler and drier 26, which may be a tower with a spray of cold water which can cool the gas and at the same time condense the moisture. The spray water may be used again after it, for example, has been cooled by indirect cooling by water from a cooling tower. To carry the cooled and dried gas back to the inert gas enclosure 1, a pipe 27 is provided which connects with the main gas inlet pipe 19 situated over the top of the mill enclosure 1. Pipe 27 is provided with a suitable fan 28 and a valve 29.

To draw air from the mill enclosure 1 to the combustion furnace 11, I provide a pipe 30 which connects with pipe 23. This pipe 30 is provided with a valve 31, a fan 32 and a valve 33.

Referring to Figure 2, pipe 34 is a pipe for supplying steam, water or other liquid for cooling the rolls of the mill. Leading from the pipe 34 are branch pipes 35, provided with suitable nozzles 36. If conditions require, these pipes may be used for steam or liquid nitrogen.

When starting up the system, when the inert gas enclosure 1 is filled with ordinary air, the supply of air for the combustion furnace 11 is drawn from the enclosure 1 through branch pipes 21, pipe 22, pipe 23, pipe 30, open valve 31, fan 32 and open valve 33. Valves 10 and 25 are closed. Gas is piped to the combustion furnace 11 through pipe 7 and open valve 8. The combustion gas produced in furnace 11 is cooled and the moisture condensed out in cooler 12. The carbon dioxide is removed in carbon dioxide absorber 13, and the gas is further dried in drier 14. The dry inert gas is then passed to storage tank 15 and is passed further through pipe 16, open valve 17, fan 18 to pipe 19 and branch pipes 20 into the top of the mill enclosure 1. I continue to draw air from the mill enclosure 1 through the bottom outlet pipe 22 to the combustion furnace 11 and return it to the enclosure 1 as an inert gas of nearly pure nitrogen, until practically all of the oxygen has been removed from the enclosure 1.

The enclosure 1 is now in proper condition for

rolling steel, and the rolling mill is set in motion. The metal to be rolled is heated to suitable rolling temperature, and is then carried into the mill enclosure 1 through opening 2 and passed between the rolls 4 to the reel 5 and out through opening 6. The rolled steel or metal should preferably remain in the inert gas enclosure 1 until it has cooled to a temperature at which it will not oxidize or scale when exposed to ordinary atmosphere.

During the rolling process, the rolls 4 are cooled when required by spray water from nozzles 36. Since the gas in the enclosure 1 tends to become hot and wet during the rolling process, it is drawn out through branch pipes 21, pipe 22 and is carried through pipe 23 by fan 24 and through open valve 25 to the cooler and drier 26, where the gas is cooled and a part or all of the moisture is removed. During this operation the valve 31 is closed.

From the cooler and drier 26, the gas passes through pipe 27, fan 28 and open valve 29 to pipe 19, from which it passes through branch pipes 20 and back into the top of the mill enclosure 1. Thus, a complete circuit is established for the inert gas, in order that it may be kept in proper condition.

In order to compensate for unavoidable losses of inert gas, I then burn gas from gas line 7, and air from open valve 10, in the combustion furnace 11, and the gas thus produced is passed through cooler 12, carbon dioxide absorber 13, drier 14, to storage 15, and the necessary amount is passed through pipe 16 and valve 17 to pipe 19, branch pipes 20, into the top of the mill enclosure 1.

If, for some reason, the inert gas in the enclosure 1 becomes contaminated with oxygen, valve 25 is closed, valves 31 and 33 are opened, and the gas is passed back to the combustion furnace 11 where it is mixed with the correct proportion of gas from the pipe 7 and burned, and the gas thus produced is passed through cooler 12, carbon dioxide absorber 13, drier 14, to storage 15, pipe 16, valve 17, to pipe 19 and branch pipes 20 into the mill enclosure 1.

It will be readily understood by those skilled in the art that by using the proper number and the proper shape of rolls, we can roll any shape of steel, and that the aforesaid process for maintaining the inert atmosphere and cooling the rolls can be adapted to the rolling of any shape of steel or other metal without departing from the scope of my invention. Furthermore, it is obvious that the showing of the apparatus is very diagrammatic, and that modifications may be made in the apparatus without departing from the spirit of the invention. For example, the gas inlet pipe 19 and branch pipes 20 may be located at the sides or ends of the enclosure 1, instead of at the top as shown. Similarly, the gas outlet pipes 21 and 22 may be located at the sides or ends of the enclosure 1, instead of at the bottom as shown. I intend, therefore, to be limited only as indicated by the scope of the appended claims.

Having thus described my invention, what I claim is:

1. In a process of rolling hot metal in an inert gas enclosure, the steps which include cooling the rolls externally by water, removing the gas from the enclosure, drying said gas, and returning said gas to said enclosure.

2. In a process of rolling hot steel in an inert gas enclosure, the steps which include cooling

the rolls externally by water, removing the gas from the enclosure, drying said gas, and returning said gas to said enclosure.

3. In a process of rolling hot metal in an inert gas enclosure, the steps which include cooling the rolls externally by water, continually removing the gas from the enclosure, drying said gas, and returning said gas to said enclosure.

4. In a process of rolling hot metal in an inert gas enclosure, the steps which include cooling the rolls externally, removing the gas from the enclosure, cooling said gas, and returning said gas to said enclosure.

5. In a process of rolling hot metal in an inert gas enclosure, the steps which include cooling the rolls externally, continually removing the gas from the enclosure, cooling said gas, and returning said gas to said enclosure.

6. In a process of rolling hot metal in an inert gas enclosure, the steps which include cooling the rolls externally by water, removing the gas from the enclosure, cooling and drying said gas, and returning said gas to said enclosure.

7. In a process of rolling hot metal in an inert gas enclosure, the steps which include external cooling of the rolls by water, removing the gas from the enclosure before it becomes appreciably corrosive to the hot metal, drying said gas, and returning said gas to said enclosure.

8. In a process of rolling hot metal in an inert gas enclosure, the steps which include external cooling of the rolls by water, removing the gas from the enclosure, drying said gas, returning said gas to said enclosure, and correcting said gas for the harmful effect of any remaining moisture by the addition of a reducing gas.

9. In a process of rolling hot metal in an inert gas enclosure, the steps which include external cooling of the rolls by water, removing the gas from the enclosure, drying said gas, returning said gas to said enclosure, and correcting said gas for the harmful effect of any remaining moisture by the addition by hydrogen as a reducing gas.

10. In a process of rolling hot metal in an inert gas enclosure, the steps which include external cooling of the rolls by water, removing the gas from the enclosure, drying said gas, returning said gas to said enclosure, and correcting said gas for the harmful effect of any remaining moisture by the addition of a hydrocarbon gas as a reducing gas.

11. In a process of rolling hot metal in an inert gas enclosure, the steps which include external cooling of the rolls by water, removing the gas from the enclosure, drying said gas, returning said gas to said enclosure, and correcting the gas for the harmful effect of any remaining moisture

by the addition of carbon monoxide as a reducing gas.

12. In a process of rolling hot metal in an inert gas enclosure, the step which consists in externally cooling the rolls of the mill by a spray of liquid nitrogen.

13. In a process of rolling hot metal in an inert gas enclosure, the steps which include externally cooling the rolls of the mill by a spray of liquid nitrogen, removing the gas from the enclosure, cooling said gas, and returning said gas to said enclosure.

14. In a process of rolling hot metal in an inert gas enclosure, the steps which include cooling the rolls externally by a spray of an inert liquid which evaporates in contact with the hot rolls, removing the gas from the enclosure, cooling said gas, recovering said inert liquid, and returning said gas to said enclosure.

15. In a process of rolling hot metal in an inert gas enclosure, the steps which include cooling the rolls externally, removing the gas from the enclosure when it becomes contaminated with oxygen, burning said contaminated gas with a correct proportion of a carbonaceous fuel, cooling the gas thus produced, removing the carbon dioxide from said gas, drying said gas, and returning said gas to said enclosure.

16. In a process of rolling hot metal in an inert gas enclosure, the step which consists in externally cooling the rolls of the mill by a spray of water, and drying said gas.

17. The herein-described method for the treatment of metal, which consists in introducing the metal in a hot rollable state to an enclosed atmosphere, maintaining the atmosphere inert, rolling the introduced metal, and subjecting the hot rolls to a coolant which is brought into contact with the rolls directly in the inert atmosphere.

18. The method as claimed in claim 17, further characterized by the fact that the temperature in the enclosure is maintained low to the point of permitting men to work therein.

19. The method of claim 17, in which the coolant is directly sprayed on the hot rolls openly in the inert enclosed atmosphere, and in circulating the inert gas while removing therefrom all the moisture acquired from the spraying step.

20. In a process of rolling hot metal in an inert gas enclosure, the steps which include external cooling of the rolls by water, removing the gas from the enclosure, drying said gas, returning said gas to said enclosure, and correcting said gas for the harmful effect of moisture by the addition of a reducing gas.

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