March 10, 1942. G. S. DUNHAM 2,275,515

METHOD OF AND APPARATUS FOR COOLING BLAST FURNACES

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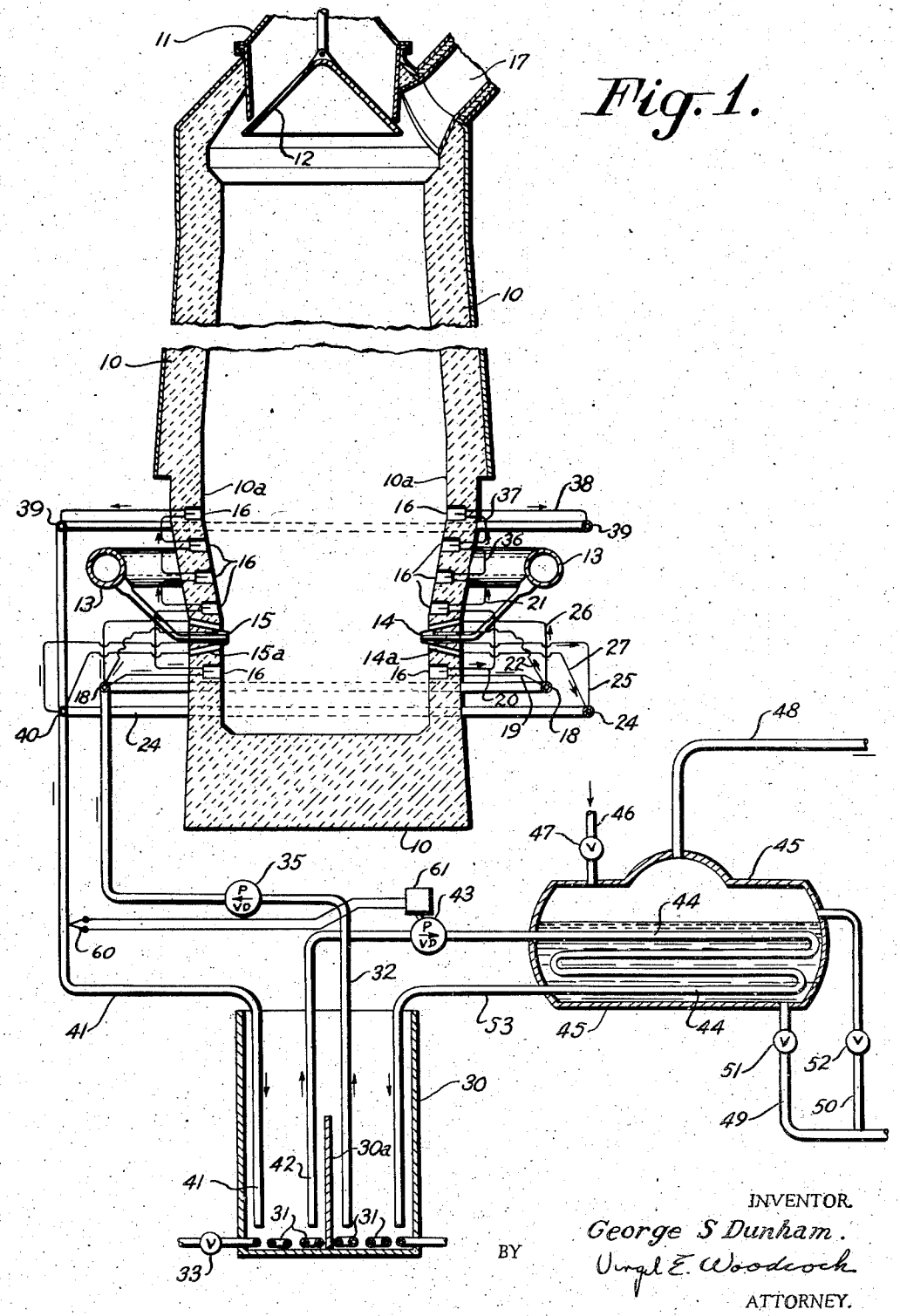


Fig. 1.

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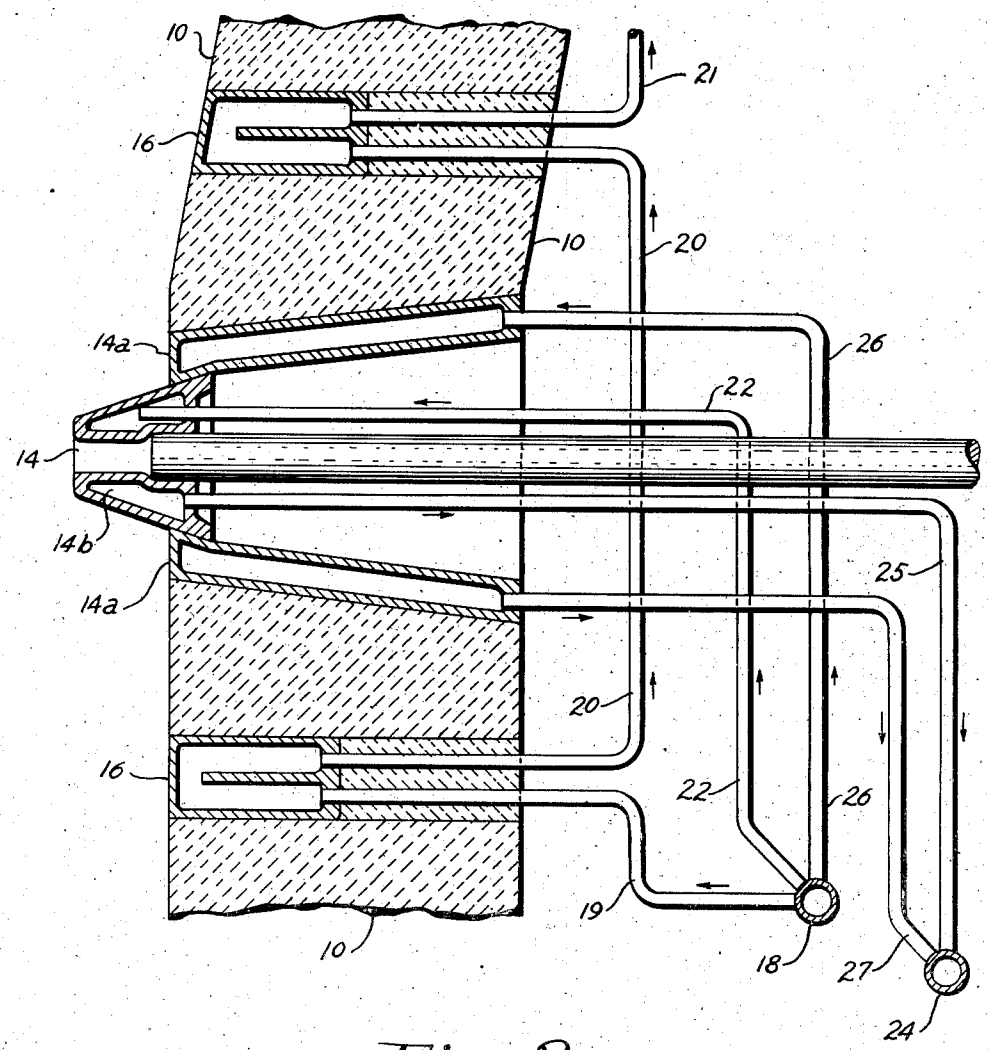


Fig. 2.

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METHOD OF AND APPARATUS FOR COOLING BLAST FURNACES

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10 Claims. (Cl. 122—6)

My invention relates to methods of and apparatus for cooling blast furnaces and has for an object not only the provision of method and means for continuously and uninterruptedly absorbing heat from parts exposed to high temperatures but also the application of the absorbed heat to useful purposes.

It is well understood by those skilled in the art that the temperatures within a blast furnace, particularly in the region of the reduced ore, or molten metal, are so high that the parts thereof such as the brickwork and the tuyères must be cooled. The accepted method of cooling is to utilize large quantities of relatively cool water circulated in heat exchange with the parts. The difficulty, however, is that water when subjected to relatively high temperature flashes into steam, which destroys the effectiveness of the water as a cooling medium. Frequently in the operation of a blast furnace, molten metal comes into contact with the tuyères, or other exposed metallic parts, and under such abnormal conditions it is imperative the cooling means be effective. However, with water, when the temperature is highest the water flashes into steam and cooling is lost at the very time when it is needed the most. In actual operation it frequently occurs that the failure of the cooling medium results in the break-down of the parts as by melting thereof, which may produce an opening through which the molten metal may flow, to the endangerment both of lives and property.

In carrying out my invention in one form thereof, I provide a cooling medium which remains highly effective regardless of temperature, and which affords protection when it is most needed, as when the parts are subjected to maximum temperatures. More particularly, I provide a heat-absorbing medium, in liquid state at temperatures above about 285° F., characterized by the fact it remains in liquid state without formation of vapor when subjected to temperatures above the highest developed in the cooling system for the blast furnace parts, which may range below 1200° F.; and further characterized by a relatively high specific heat, above three-tenths; and by relatively high permissible operating temperatures, as from 400° F. to 850° F., in contrast with water which must be maintained below its boiling point. By reason of the absence of vapor, the cooling function of the medium is unimpaired, regardless of temperature, and cooling is as effective at extremely high temperatures as at lower temperatures.

Because of the relatively high operating temperature of around 850° F. permissible in the cooling fluid, it may be utilized as the heating medium for a steam boiler. The generation of steam by the heat removed from the blast furnace represents approximately a 100% saving since with water as a cooling medium a large quantity thereof must be used, with relatively low outlet temperatures, and economical use of the absorbed heat is not feasible.

My invention, together with other objects and advantages thereof will be more fully understood upon reference to the following description and the accompanying drawings forming a part of this specification and of which:

Fig. 1 more or less diagrammatically illustrates my invention as embodied in a cooling system for a blast furnace; and

Fig. 2 is an enlarged sectional elevation of a portion of the blast furnace wall, including a tuyère and two of the wall-cooling heat exchangers.

Referring to the drawings, I have shown my invention in one form as applied to a blast furnace **10**, charged by way of a fractionally illustrated hopper **11** under the control of a bell **12**. As understood by those skilled in the art, a suitable mixture of iron ore, coke, flux, and other ingredients is charged through the hopper **11**. This mixture may be charged to provide alternate layers of coke, ore, and flux. The hot blast, or the air for smelting is driven into the furnace **10** by way of a header **13**, from which extends annularly about the furnace a plurality of tuyères, only the tuyères **14** and **15** being illustrated. The hot blast, at a temperature of from 800° to 1200° F., assists in the combustion of coke and the reduction of the iron ore. The combustion gases are withdrawn from the furnace by way of flue **17**. The temperature within the blast furnace progressively increases from the top of the charge towards the bottom thereof until it attains a maximum temperature within the portion thereof indicated at **10a**, and which portion is known as the bosh. The bosh extends from just below, to the region a few feet above, the tuyères **14** and **15**. The temperatures within the bosh may range from 2000° to perhaps 3000° F. At such temperatures, the high-temperature refractory walls of the furnace **10** tend to soften or to slag, which is prevented by the inclusion in the walls of a plurality of heat exchange devices **16**, which may be in the form of hollow metallic castings placed in the wall adjacent the inner surface, or directly exposed at one end to the interior of the furnace. Similarly, the tuyères **14** and **15** are provided with cooling means or jackets **14a** and **15a**.

Additionally, the end of each tuyère projecting into the bosh is provided with heat exchange means, Fig. 2, the tuyère **14** having a cooling jacket **14b** thereof around its inner, or projecting end. All cooling devices are preferably formed of a metal chemically inert to the cooling fluid or medium, and in the preferred form of my invention those devices may be of ferrous metal or its alloys.

My invention is particularly characterized by a cooling method and heat exchange system in which a maximum protection of the individual parts, including the walls, tuyères, and heat exchange elements, is provided during abnormally high temperature conditions. In accord with my invention a heat-absorbing medium is utilized, which is itself characterized by a very low vapor pressure, and so low that no vapor is formed within the range of temperature attained by the parts of the blast furnace in contact with the heat-absorbing medium. More specifically, the heat-absorbing medium may comprise, by way of example, between 43% and 45% of sodium nitrite and between 57% and 55% of potassium nitrate. These substances, which are normally solids and individually of relatively high melting temperatures, produce, when mixed together in molten state, a resulting mixture thereof, the heat-absorbing medium, having a relatively low melting temperature, of around 285° to 300° F. This heat-absorbing medium has substantially no vapor pressure at temperatures up to 1200° F. and produces little if any vapor within the temperature range of the blast furnace cooling system. The heat-absorbing medium has a specific heat, above three-tenths; its viscosity decreases with temperature; it is chemically stable at the highest of the temperatures attained, specifically of the order of 1200° F.; it has all of the advantages of water and none of the disadvantages. For example, it does not include other compounds which form scale, as in the case of water. It does not, when the cooling is needed the most, form substantial quantities of vapor and thereby destroy the needed cooling, as in the case of water. It affords a practical means and method of conserving the heat absorbed from the furnace, as by making it available for the generation of steam.

While I prefer as my heat-absorbing medium the mixture of sodium nitrite and potassium nitrate, other heat-absorbing mediums may be utilized in accord with my invention, such for example as a chemical now available on the market under the trade name of "Dowtherm" (Dow Chemical Company). Mixtures of salts of other metals may be used so long as such salts are liquid within the desired range of temperatures and have the characteristics of extremely low vapor pressure at temperatures existing in the operation, and a suitably high specific heat.

The heat-absorbing medium may be circulated through the various heat exchange means in any desired order. For example, Fig. 2, the heat-absorbing medium may flow from an inlet conduit or header **18** by way of conduit **19** to the lowermost device **16** and by way of conduit **20** to the next adjacent device **16** and from there to the next device by way of conduit **21**. By a separate conduit **22**, extending from the header **18**, a second stream of the heat-absorbing medium may be conducted to the jacket **14b** surrounding the inner end of the tuyère **14**, the medium being returned to an outlet header **24** by way of conduit **25**. A third stream may be derived from header **18** by way of conduit **26** for flow through the outer jacket **14a** of the tuyère **14**, the medium returning to the outlet or return header **24** by way of conduit **27**. Depending upon the requirements of pressure drop and the quantity of heat-absorption medium which must be circulated per unit of time, the various heat exchange devices may be all connected in series, or all in parallel, or in selected combinations of series and parallel groups.

In describing the operation of my invention as applied to the blast furnace **10**, it will be assumed that the heat-absorbing system is to be placed in operation. Since the heat-absorption medium is a solid at temperatures below 285° to 300° F., the system is arranged so that the heat-absorption medium, when the blast furnace is shut down, automatically drains into an accumulator storage tank **30**, Fig. 1. In order initially to melt the solid medium contained in the tank **30**, a heating coil **31**, receiving steam under the control of valve **33**, may be disposed along the bottom of tank **30**; or an electrically heated coil may be located in tank **30** to melt the medium adjacent the lower end of the conduit **32**. As soon as the medium is melted, it is withdrawn by means of a variable delivery pump **35** and delivered under pressure to the inlet header **18**. The auxiliary heater **31** is then disconnected.

As explained in connection with Fig. 2, the medium flows from header **18** by way of conduits **19**, **22**, and **26** to the several heat exchange devices illustrated in the right-hand part of furnace **10** as viewed in Figs. 1 and 2. As shown, the circuit including the conduits **19**, **20**, **21** also includes conduits **36** and **37**, each leading to one of devices **16**, and return conduit **38** leading to an outlet header **39**, which joins with the header **24** at **40** for the return of heat-absorption medium by way of conduit **41** to the storage tank **30**. In Fig. 1 the conduits from headers **18** and to headers **24** and **39** are shown by single lines for the sake of added clarity.

During normal conditions of operation the inlet and outlet temperatures of the heat-absorption medium remain relatively constant. For example, the temperature of the medium returned to the tank **30** may be of the order of 850° F. As shown, the tank **30** is divided by means of a baffle **30a**, from which all or any desired part of this 850° medium is immediately withdrawn by way of conduit **42** and discharged by a variable delivery pump **43** into heating coil **44** of a steam boiler **45**. The water level may be maintained within the boiler **45** by means of water inlet **46**, under the control of valve **47**, while steam may be withdrawn from the boiler **45** through the steam outlet conduit **48**. The usual blow-down connections may be provided, as indicated by the lines **49** and **50**, respectively under the control of valves **51** and **52**. In heating the water within the boiler **45** to produce steam, the heat-absorbing medium is cooled down to a temperature which may be of the order of 400° F. From the coil **44** the medium is returned by way of conduit **53** to the right-hand portion of tank **30**, where it mingles with any part of the heat-absorbing medium not pumped through coil **44**. The cooled mixture immediately flows by way of conduit **32** to the heat exchange devices of the furnace **10**.

By independently regulating the flow of fluid delivered by pumps **35** and **43**, predetermined

quantities of heat-absorbing medium per unit of time may be circulated through the boiler 45 and the heat exchange devices of the blast furnace 10. The pump 35, or a plurality of them, is operated to produce a relatively high velocity of flow of the medium in the heat exchange devices for intimate heat exchange and effective absorption of heat. The rate of flow per unit of time may be materially greater through the system controlled by the pumping means 35 than the rate of flow induced by the pumping means 43 through the boiler 45. It will, of course, be understood that baffle 30a is not essential, and may be omitted. Moreover, a single pump may be utilized, in which case fluid flowing through the conduit 41 would directly enter the boiler 45 by way of conduit 42 and the medium leaving the boiler 45 would by conduit 53 flow directly to the tank 30 and thence to the inlet of the pump 35. With the foregoing in mind, a number of other possible arrangements of flow will now suggest themselves, and in accord with my invention the flow may be arranged to best meet the requirements of a particular installation.

In the preferred form of my invention, however, the boiler-circulating means 43 is controlled in response to the temperature of the medium leaving the cooling system. For example, a thermocouple 60, responsive to the temperature of the medium leaving the fluid system, is directly connected to a controller 61, of a conventional mechanical or electrical type, of which there are many known to the art. A rise in temperature within the blast furnace is reflected by a greater absorption of heat by the cooling medium. For given operations of pumps 35 and 43, the temperature of the medium rises. In accord with my invention, this rise in temperature above a predetermined temperature, through the thermocouple 60 and controller 61, increases the rate at which the pump 43 circulates the medium through the boiler-heating coil 44. The increased flow of the medium produces a greater heat transfer, increased generation of steam, and reduces the temperature of the medium returned to the tank 30. Preferably the rate of flow is so regulated as to insure a fairly constant temperature of the medium leaving the cooling system of the blast furnace. The resulting variable rate of steam generation is unobjectionable. Obviously the thermocouple may be located to be responsive to the temperature of the medium entering the blast furnace by way of pump 35, in which case the rise and fall of temperature above a selected temperature varies the circulation through the boiler-heating coil 44. Or, the pumping rates of both pumps 35 and 43 may be thermostatically or automatically regulated to predetermine the temperature of the heat absorption medium, and the temperature difference between the boiler and blast furnace inlets and outlets.

If, during the operation described above, molten metal should be deposited upon any of the heat exchange devices suddenly to elevate their temperatures, the heat absorption medium characterizing my invention would continue to be highly effective rapidly and uninterruptedly to remove heat from such device to prevent failure thereof and ultimate loss of molten metal, or pig iron, and failure of the blast furnace as a whole. There is no loss of cooling effect at a time when it is most needed since the heat-absorption medium does not vaporize or in other respects lose its heat-absorbing capacity.

The relatively high operating temperature of the heat-absorbing medium makes it possible to generate relatively large quantities of steam which may be used for the generation of power, as by turbine-generator sets, for the heating of buildings, or for other industrial purposes.

While I have shown an embodiment of my invention, it is to be understood that I do not limit myself thereto since many modifications may be made and I, therefore, contemplate by the appended claims to cover any such modifications as fall within the spirit and scope of my invention.

What I claim is:

1. In a blast furnace, cooling means for the bosh and tuyères thereof comprising a heat absorbing medium characterized by substantially no vapor pressure and in liquid phase during operating temperatures, and mechanical means for positively circulating said medium at high velocity in intimate heat exchange with said bosh and tuyères.

2. Cooling means for a blast furnace comprising a heat absorbing medium characterized by a vapor pressure so low that negligible vaporization occurs at temperatures below about 1200° F., and a melting temperature less than the range of operating temperatures of said blast furnace walls, heat exchange means disposed in heat-absorbing relation to said furnace, and mechanical means for positively circulating said medium at high velocity through said heat exchange means.

3. In a blast furnace, cooling means for the bosh and tuyères thereof comprising a heat absorbing medium characterized by the substantial absence of a vapor pressure at, and a melting temperature less than, the operating temperatures of said bosh and tuyères, an accumulator for said medium, means connected to said accumulator for positively circulating said medium at high velocity in intimate heat exchange with said bosh and tuyères, and separate means including a heat-absorber for independent, positive circulation of said medium therethrough for controlling the temperature of said medium within said accumulator.

4. The combination with a vessel containing molten metal and in which parts thereof exposed to high temperatures therein must be cooled, of heat exchange means associated with said parts, a heat absorbing medium in liquid state at temperatures below 400° F., and characterized by the fact it remains in liquid state with negligible vaporization when subjected to temperatures above the highest attained by said parts, and means for uninterruptedly cooling said parts regardless of temperatures thereof comprising means for positively circulating said medium at high velocity through said heat exchange means.

5. The combination with a blast furnace in which parts thereof exposed to high temperatures must be cooled, of a plurality of heat exchange devices associated with said parts, a plurality of conduits connecting said parts in groups for the circulation of a heat-absorbing medium therethrough, inlet and outlet headers for said conduits, all of said conduits and devices being connected for gravity flow of the heat absorption medium therefrom, pumping means included in circuit with said inlet header for positively circulating said medium through said devices at a predetermined high rate, said heat-absorbing me-

dium being characterized by the fact it has a vapor pressure so low it remains in liquid state regardless of the temperature to which it is subjected for all temperatures below 1200° F., and by the fact it is a solid at temperatures below about 285° F., and a storage tank for receiving by gravity flow all of the medium in the system.

6. In a blast furnace in which parts thereof are exposed to temperatures so high that the parts must be cooled, the method which comprises positively circulating at high velocity in heat exchange with said parts a cooling medium characterized by the fact it remains in liquid state with negligible formation of vapor when subjected to temperatures as high as those to which said parts are subjected and generally less than 1200° F. and which has a specific heat above about three-tenths.

7. In a blast furnace in which parts thereof are exposed to temperatures so high that the parts must be cooled, the method which comprises circulating at high velocity in heat exchange with said parts a cooling medium characterized by the fact it remains in liquid state with negligible formation of vapor when subjected to the highest temperatures attained by said parts which may be above about 1400° F. and of the order of 800° F., said medium being further characterized by a specific heat of above about three-tenths, and by chemical stability with respect to all temperatures attained by said parts.

8. A method as set forth in claim 7 in which the temperature of the cooling zones of the blast furnace is maintained substantially constant by transfer from said medium of the heat absorbed from the blast furnace, and varying the rate of said transfer from said medium to maintain fairly constant the temperature of the medium entering said parts.

9. The combination with a vessel containing molten metal and in which parts thereof exposed to high temperatures therein must be cooled, of heat exchange means associated with said parts, a heat-absorbing medium in liquid state at temperatures above about 285° F. and characterized by the fact it remains in liquid state with negligible vaporization when subjected to temperatures above the highest attained by said parts, means for uninterruptedly cooling said parts regardless of temperatures thereof, comprising means for positively circulating said medium at high velocity through said exchange means, a heat-absorbing device for reducing in temperature said medium, and means for positively circulating said medium through said heat-absorbing device at a rate independent of the circulation through said heat exchange means, and means for controlling the circulation through said heat-absorbing device to maintain relatively constant the temperature of said medium entering said heat exchange means.

10. In a system in which the heat removed in the cooling of parts of a blast furnace is utilized for the generation of steam, the combination of cooling means for the blast furnace comprising a heat-absorbing medium characterized by a vapor pressure so low that negligible vaporization occurs at temperatures below about 1200° F. and a melting temperature below the range of operating temperatures of said blast furnace parts, including the blast furnace walls, heat exchange means disposed in heat-absorbing relation to said furnace, mechanical means for positively circulating said medium at high velocity through said heat exchange means for the removal of heat to maintain the parts, including the furnace walls within their operating temperatures, heat absorbing means, and mechanical means producing positive circulation of said medium through said heat absorbing means for reducing the temperature of said medium before return thereof to said heat exchange means.

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