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(54) Cooling of hot bodies.

(57) A hot body, such as part of a vessel for molten metal, is cooled by having atomised liquid coolant directed on to it. The coolant is directed into a space between the surface to be cooled and another surface parallel to it in a direction parallel to the surfaces. The volume of liquid coolant which is supplied does not exceed the volume of liquid which is vaporised by the hot body.

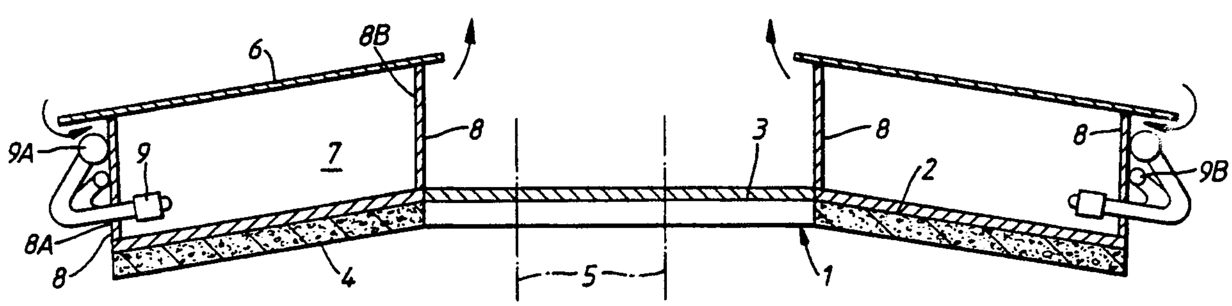

Fig. 2.

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COOLING OF HOT BODIES

This invention relates to a method of cooling a hot body and to a body which, in use, has to be cooled with liquid coolant. A particular, but not sole, application of the invention is to a method of cooling a part of a vessel for containing molten metal and to such vessels.

In pyro-metallurgical processes, heat is generated during the smelting, melting, or refining of the metal. The process ingredients are usually confined within a steel vessel which is lined with refractory material in order to protect the steel shell, as far as possible, from the high temperatures used in the process. Nevertheless, the shell usually becomes hot so it is beneficial to provide cooling of at least part of the shell in order that distortion is reduced and the shell material retains sufficient of its strength to operate according to the designer's intentions.

In recent years, the use of magnesite carbon refractories as the lining material has given a longer working life to the lining, but it has resulted in higher shell temperatures. It is now well recognised in the metallurgical industry that it is extremely dangerous to allow liquid water and liquid metal to come into close proximity to one another because, in the event of a fault occurring, the sudden expansion and vaporisation of water on contact with liquid metal can cause a dangerous explosion.

It is known from EP-A-0044512 to cool a section of the exterior of a metallurgical furnace by forming a closed box around the surface to be cooled to form a chamber closed from the atmosphere except for an exhaust pipe. Coolant water, in the form of jets of finely divided droplets, is directed in overlapping sprays on to the surface to be cooled. The sprays are contained within the chamber and are directed normal to the plane of the surface to be cooled. The volume of coolant applied in a given time period does not exceed the volume of liquid coolant which is vaporised by contact with the surface to be cooled in the given time period. The vaporised water leaves the chamber through the exhaust pipe.

According to a first aspect of the present invention, in a method of cooling a hot body having a surface of an additional body arranged substantially parallel to, and spaced from, a surface of the body to be cooled, a quantity of liquid coolant is atomised by a gaseous medium and is discharged in overlapping sprays in the space between the two surfaces in a controlled manner whereby the volume of coolant applied in a given time period does not exceed the volume of liquid coolant which is vaporised by contact with the surface of the hot body in the given time period, characterised in that the space between the surfaces is open to the atmosphere and the liquid coolant sprays, which are substantially flat, are directed in the spaces in directions substantially parallel with the surfaces and in a manner such that they overlie substantially the entire surface of the body to be cooled.

The liquid coolant is conveniently water and, since the water is applied in the form of fine droplets on to the outer surface of the body to be cooled, cooling by vaporisation takes place. In this way, advantage can be taken of the fact that a much greater quantity of heat can be removed by each unit mass of water employed when it is vaporised than when it remains liquid. As the water is applied at a rate not exceeding the rate at which the water is vaporised by contact with the surface, there is no water remaining to run off the surface being cooled into possible contact with the molten metal contained within the vessel.

The feature of spraying the liquid coolant in directions substantially parallel with the surface to be cooled means that the water droplets spread over a greater area and uniform cooling of the part of the container can be achieved and only a very few spray nozzles are required in order to bring about the desired cooling as compared with a much greater number of nozzles which are required when the liquid coolant is sprayed substantially at right angles on to the surface to be cooled from nozzles close to the surface.

The fact that the space between the surfaces is open to the atmosphere permits air to be drawn into the space by the action of the sprays and the air and the sprays achieve a combined flow pattern which disperses the coolant over the entire surface to be cooled.

According to a second aspect of the invention, a body which, in use, has to be cooled with liquid coolant has an additional body arranged with a surface substantially parallel to, and spaced from, a surface of the body to be cooled, a plurality of nozzles arranged to receive a gaseous medium and a liquid coolant and to discharge the liquid coolant in the form of atomised overlapping sprays of coolant in the space between the surfaces, characterised in that the space between the surfaces is open to the atmosphere and the nozzles are arranged to discharge the flat sprays in directions substantially parallel with the surfaces and in a manner such that they overlie substantially the entire surface of the body to be cooled.

In use, the amount of liquid coolant applied to the surface of the part of the vessel to be cooled is preferably controlled by means which determines the temperature of the outer surface of the part to be cooled and valve means for controlling the supply of liquid coolant in response to the determined temperature such that the droplets which are applied over a time period on to the surface do not exceed the droplets which are vaporised by contact with the surface during that time period.

The surface of the body to be cooled is conveniently the roof of the relevant vessel, which further may comprise, e.g. a ladle furnace or an electric arc furnace. In the case of the barrel and trunnion ring of a basic oxygen furnace, both surfaces are cooled. It may also take the form of a fume/flame extraction hood for use during transfer of molten metal from a ladle to a converter vessel.

In order that the invention may be more readily understood, it will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a plan showing the roof of a ladle furnace;

Figure 2 is a section on the line X-X of Figure 1;

Figure 3 is a perspective view of the nose cone of a basic oxygen furnace; and

Figure 4 is a section through the nose cone.

The roof 1 of a ladle furnace is of annular form and consists of a metal plate 2 having a central opening 3 and a lining 4 of refractory material attached to the underside of the metal plate. The plate is inclined upwardly from its outer edge towards the central opening 3. Electrodes 5 are raised and lowered and enter into the ladle furnace through the opening 3.

In use, the exterior roof surface becomes very hot and its temperature has to be reduced by applying liquid coolant to it. To this end, an additional body 6 in the form of an annular plate is mounted above the said roof surface and a space 7 is formed between the outer surface of the plate 2 and the inner surface of the body 6. These surfaces are arranged to be substantially parallel but the orientation thereof may be varied, in the event that a physical obstruction is present. Apart from support struts 8, provided at the outer edge of the roof surface and around the opening 3, the sides of the space 7 are open to atmosphere. A plurality of spray nozzles 9 are located inside the space 7 adjacent to the outer edge of the roof surface. These spray nozzles are supplied with liquid coolant, usually water, from a ring main 9A and also with air under pressure from a pipe 9B and, in use, they provide a wide-angled flat spray of water droplets, indicated by broken lines 10 in Figure 1. Alternatively the spray nozzles could be operated by high pressure means to discharge atomised sprays.

The centre-line of each spray is substantially parallel to the surfaces 2 and 6 and is directed towards the opening 3 but is not radial to the opening 3. The sprays are arranged so that the boundary of one spray overlaps with the boundary of the adjacent sprays so that substantially the entire surface 2 receives droplets of atomised coolant liquid issuing from the nozzles 9. The wide-angled flat sprays are used to cover a large surface area and the nozzles are arranged to cause the water droplets to initially travel essentially parallel to the surface in a swirling action. This is achieved for a wide range of water flow rates by the use of the atomising air.

The action of the sprays draws in additional air through the open parts of the outer edge between the exterior roof surface and the body 6 and the free access of air ensures a good flow of the droplets across the surface 2 and improves the range of the sprays and the heat transfer coefficient between the coolant and the surface to be cooled. The entrained air and vapour resulting from evaporation of the coolant leaves the space between the open upper edge 8B of the space.

The area covered by the water from each nozzle is very large and, if the nozzles were directed at right angles to the surface 2, the area covered by each nozzle would be very considerably reduced and ten to twenty five times as many nozzles would be required for the same cooling capacity.

Figures 3 and 4 show the nose cone of a basic oxygen furnace. The cone consists of a steel shell 12 having an internal lining 14 formed from blocks of refractory material. The conical nose section of the shell is surrounded by a slag shedder plate 17 which protects the conical section of the shell from slag and molten metal spilled from the mouth of the vessel and the shedder plates 17 are, in fact, substantially parallel to the outer surface of the shell 12. The shedder plates are held in position by struts 18 and the space 19 between the plates 12 and 17 is open at its lower and upper ends. A plurality of headers 20 are arranged radially on the nose cone 12 in the space 19 and the headers are connected to a water main 21 and an air main 21A. A plurality of nozzles 22 are provided on each header. The spray nozzles are provided with liquid coolant and air under pressure and are arranged to produce a wide-angled spray of atomised droplets, which may initially be generally flat, and the sprays are arranged to extend substantially parallel to the outer surface of the plate 12 and the inner surface of the shedder plate 17. The rate at which the droplets are applied to the surface is controlled such that the coolant is vaporised by contact with the hot surface and the surface is not cooled to such an extent that water runs off the surface. The boundaries of the sprays are overlapped and the air is used to atomise the water issuing from the sprays so that a mist is caused to move with a swirling action around the space 19. The swirling action also has a component in the direction towards the upper end of the plate 12 whereby that swirling vortex moves across the face of the entire plate 12 to its upper edge where the vapour generated as a result of the cooling of the surface leaves the space, along with the entrained air drawn in through the bottom, out through the space at the upper end of the shedder plate.

In all the embodiments of the invention control means are provided for determining the temperature of the surface to be cooled and for controlling the flow of water from the nozzles such that adequate cooling is provided but that all the cooling water is vaporised and no water runs off the surface.

In most applications, the purpose of the liquid coolant is to cool the hot body but, of course, some of the coolant will contact the additional body and provide a degree of cooling. This is particularly advantageous when the additional body has to be cooled to prevent it from distorting, such as is the case with the slag shedder system on a basic oxygen furnace, or when cooling the barrel of a basic oxygen furnace and the additional body is the trunnion ring which forms part of the furnace suspension system.

The system is basically fail-safe in that the headers and pipes leading to the nozzles are open-ended. Thus, in the event of water supply failure, pipework damage, due to rapid expansion experienced during evaporation of the water inside the pipes, etc., is avoided.

Claims

1. A method of cooling a hot body having a surface of an additional body arranged substantially parallel to, and spaced from, a surface of the body to be cooled wherein a quantity of liquid coolant is atomised by a gaseous medium and is discharged in overlapping sprays in the space between the two surfaces in a controlled manner whereby the volume of coolant applied in a given time period does not exceed the volume of liquid coolant which is vaporised by contact with the surface of the hot body in the given time period, characterised in that the space between the surfaces is open to the atmosphere and the liquid coolant sprays, which are substantially flat, are directed in the spaces in directions substantially parallel with the surfaces and in a manner such that they overlie substantially the entire surface of the body to be cooled.

2. A method as claimed in claim 1, characterised in that the surface of the body to be cooled is monitored to determine its temperature and the liquid coolant is applied at a controlled rate determined by the monitored temperature.

3. A method as claimed in claim 1 or 2, characterised in that the liquid coolant is water and the gaseous medium is air under pressure.

4. A body which, in use, has to be cooled with liquid coolant, said body having an additional body arranged with a surface substantially parallel to, and spaced from, a surface of the body to be cooled, a plurality of nozzles arranged to receive a gaseous medium and a liquid coolant and to discharge the liquid coolant in the form of atomised overlapping sprays of coolant in the space between the surfaces, characterised in that the space between the surfaces is open to the atmosphere and the nozzles are arranged to discharge the sprays, which are substantially flat, in directions substantially parallel with the surfaces and in a manner such that they overlie substantially the entire surface of the body to be cooled.

5. A body as claimed in claim 4, characterised in the provision of means for monitoring the surface of the body to be cooled to determine its temperature and means for controlling the discharge of coolant at a rate determined by the monitored temperature.

6. A body as claimed in claim 4 or 5, characterised in that the body forms part of, or is associated with, a vessel for containing molten metal and/or slag.

7. A body as claimed in claim 6, characterised in that the body constitutes the outer metal shell of the vessel.

8. A body as claimed in claim 7, characterised in that the body is a basic oxygen furnace.

9. A basic oxygen furnace as claimed in claim 8, characterised in that the body to be cooled is a conical nose section of the shell and the additional body is the shedder plate system.

10. A basic oxygen furnace as claimed in claim 8 or 9, characterised in that the body to be cooled is part of the barrel of the vessel and the additional body is a trunnion ring.

11. A body as claimed in claim 7, characterised in that the vessel is an electric arc furnace or a plasma arc furnace.

12. A body as claimed in claim 7, characterised in that the vessel is a ladle furnace.

13. A body as claimed in claim 6, characterised in that the body is an extraction hood for use during the transfer of molten metal from a ladle to a converter vessel.

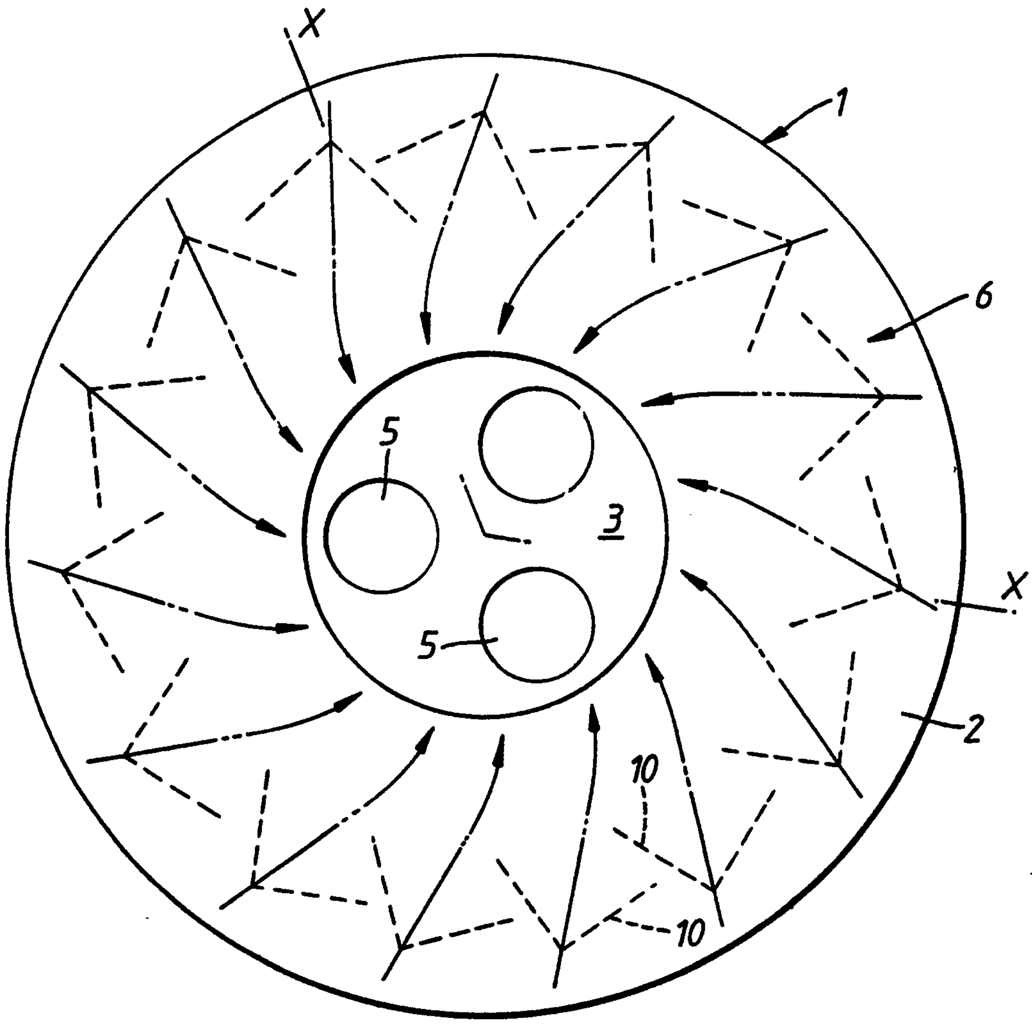

Fig. 1.

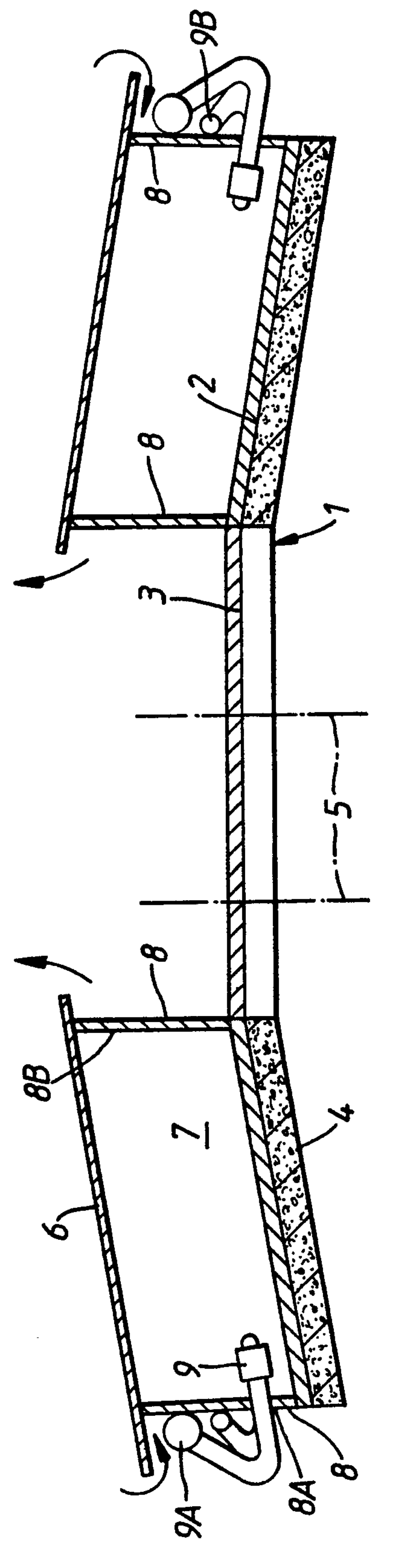

Fig.2.

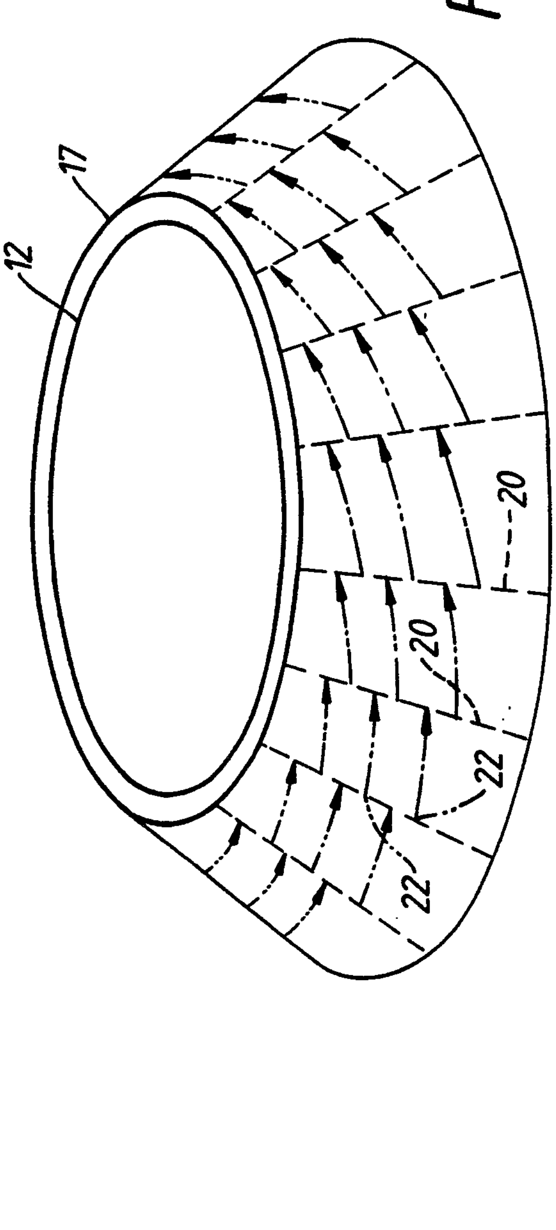

Fig.3.

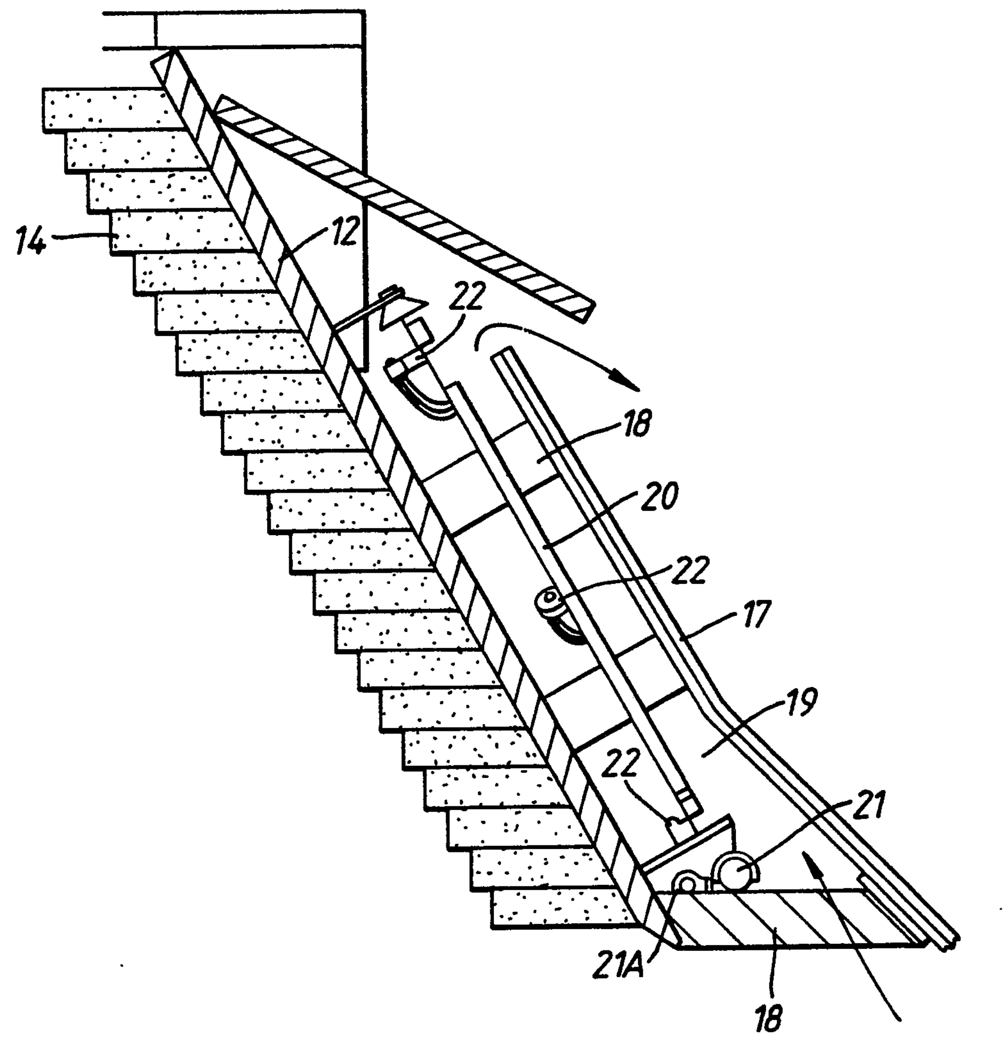

Fig. 4.