

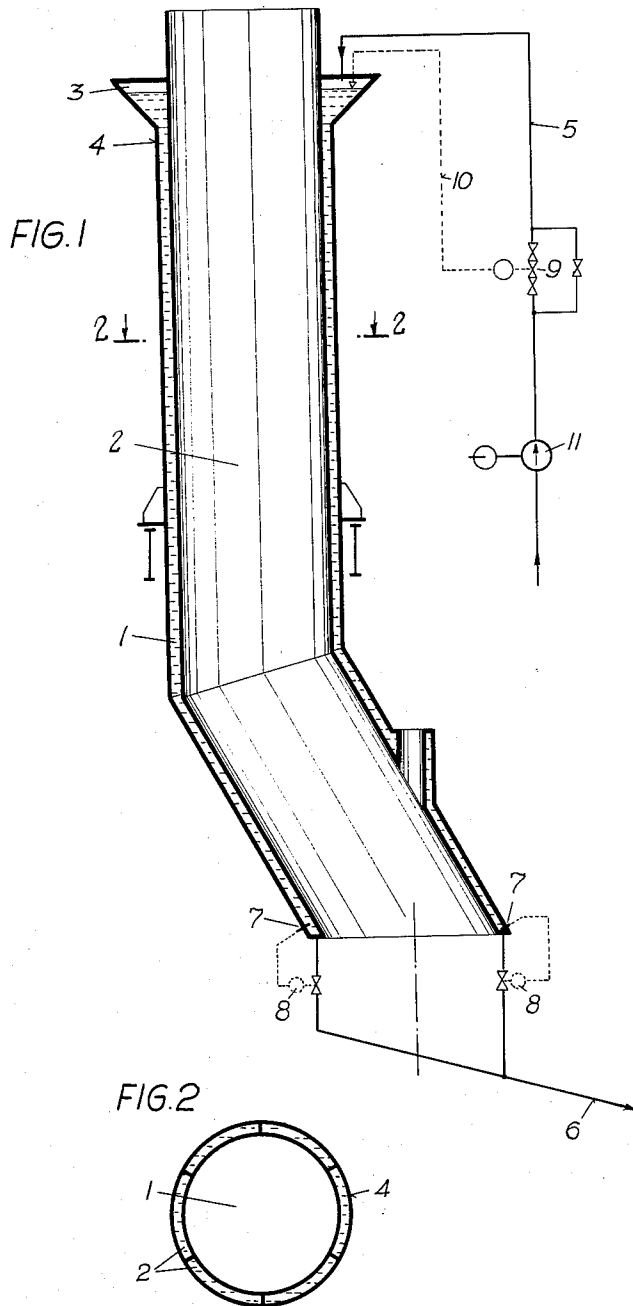
Oct. 19, 1965

D. K. MARKOW ETAL  
METHOD OF AND APPARATUS FOR COOLING INDUSTRIAL  
FURNACE INSTALLATIONS

3,212,476

Filed June 11, 1962

6 Sheets-Sheet 1



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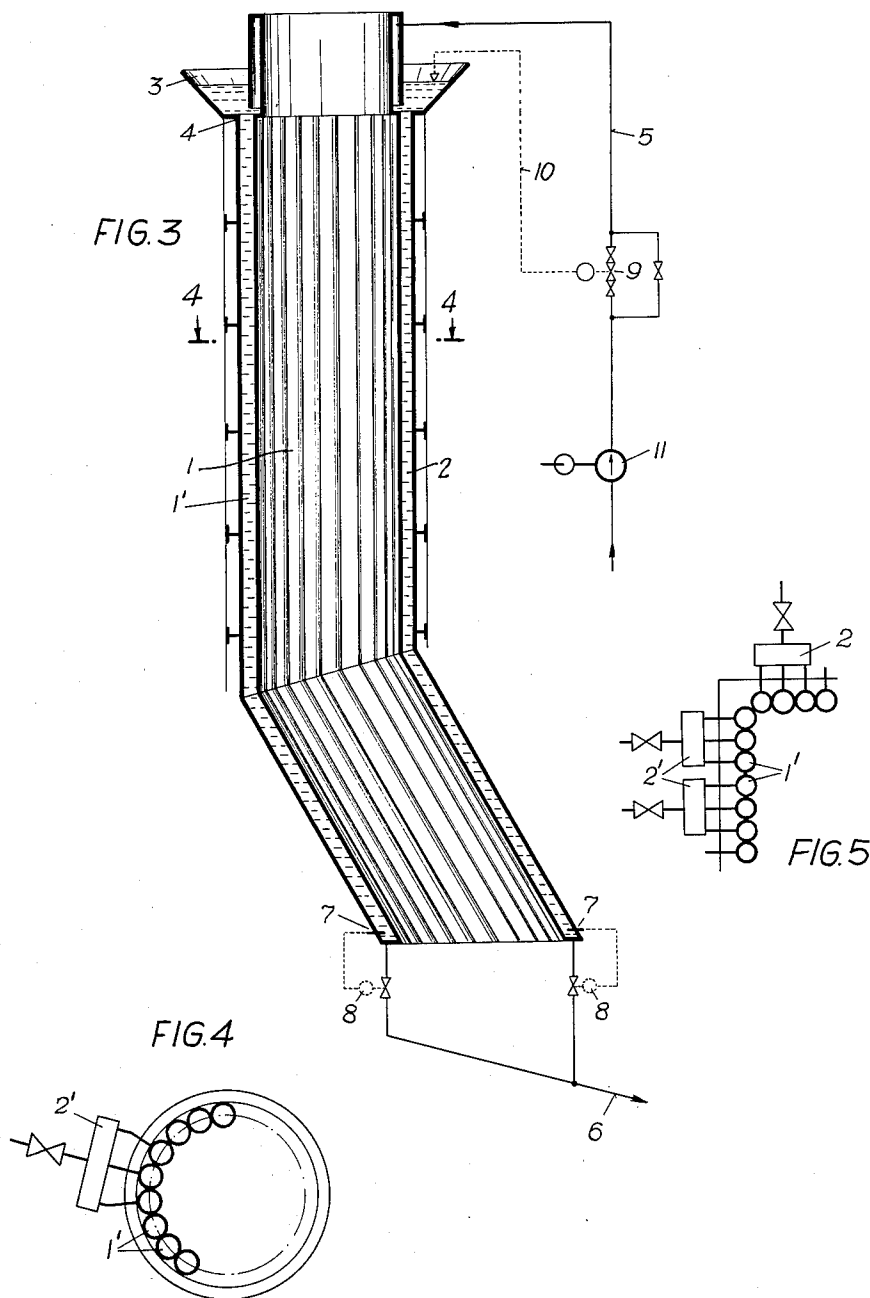
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Filed June 11, 1962

6 Sheets-Sheet 2



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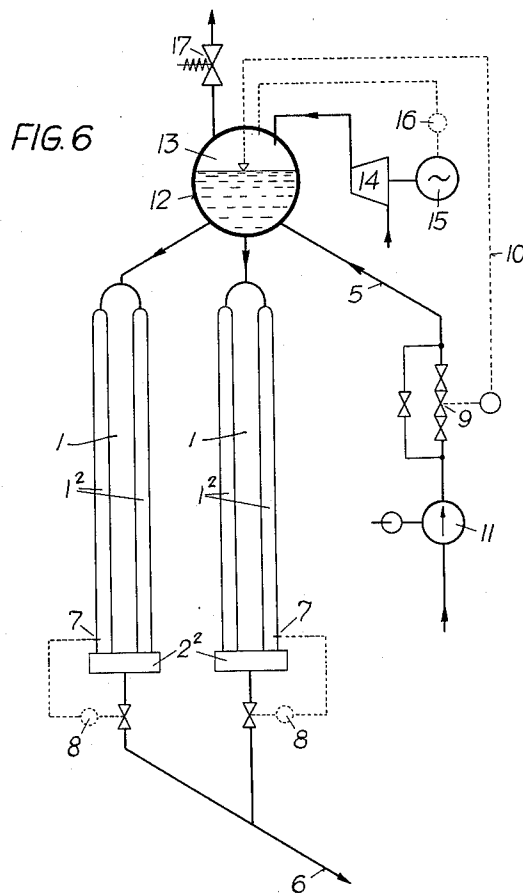
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3,212,476

Filed June 11, 1962

6 Sheets-Sheet 3



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3,212,476

Filed June 11, 1962

6 Sheets-Sheet 4

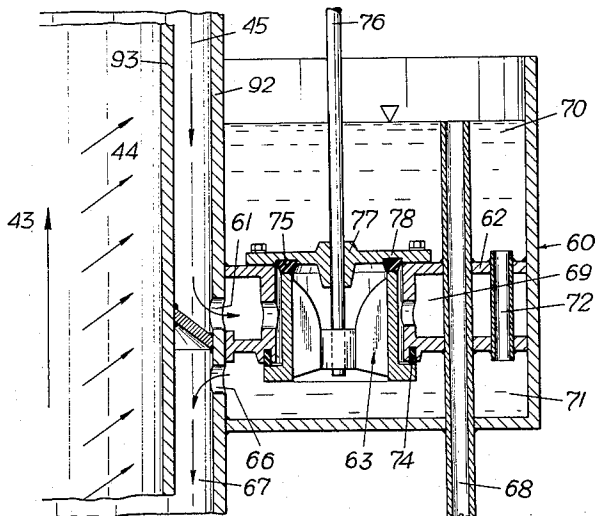
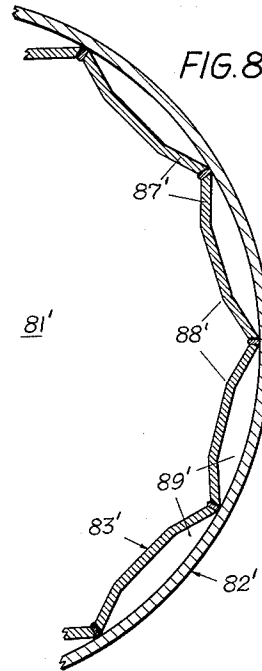
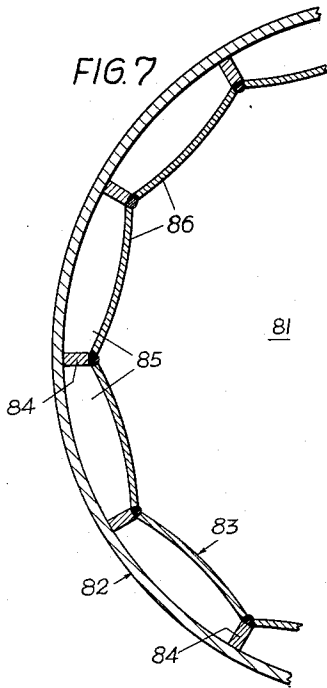


FIG. 11

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Filed June 11, 1962

6 Sheets-Sheet 5

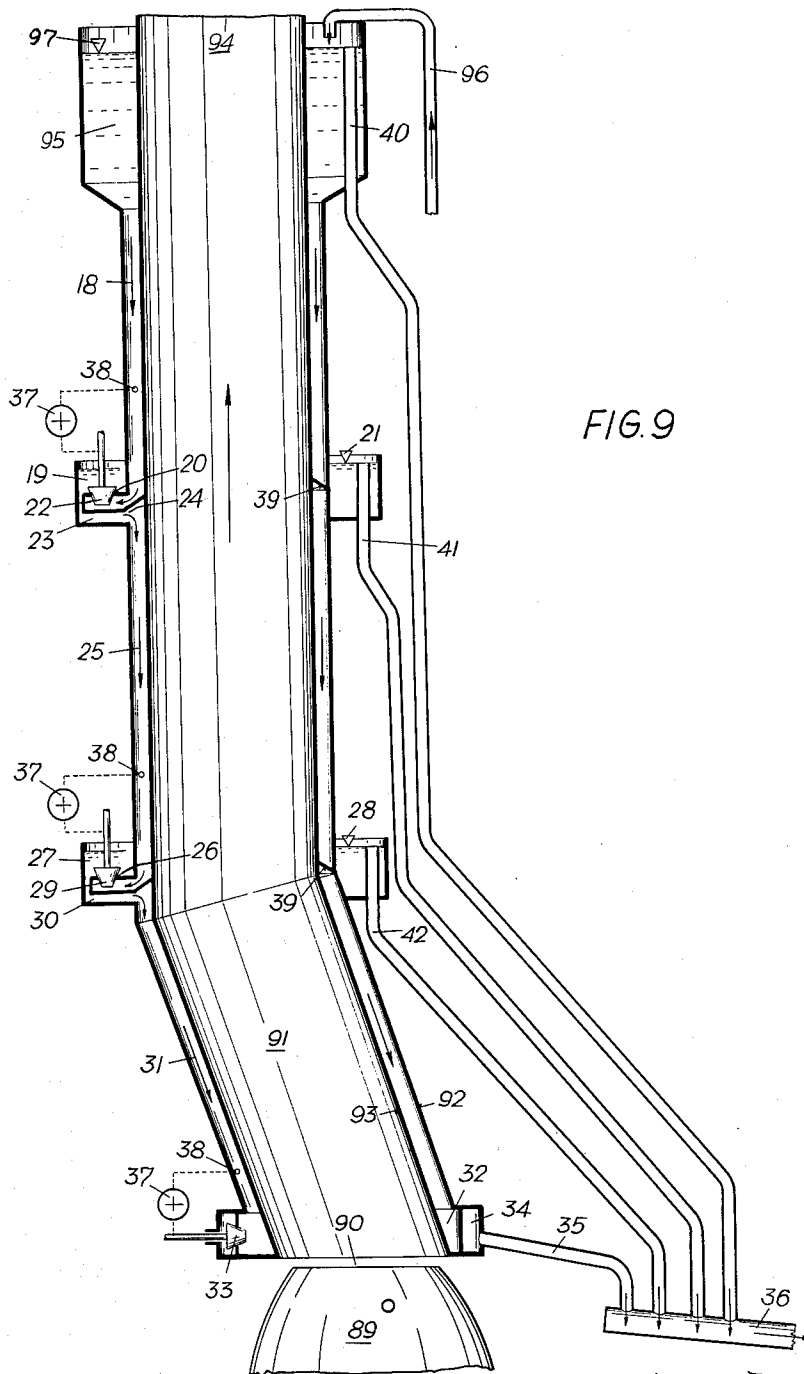


FIG. 9

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**Oct. 19, 1965**

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METHOD OF AND APPARATUS FOR COOLING INDUSTRIAL  
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Filed June 11, 1962

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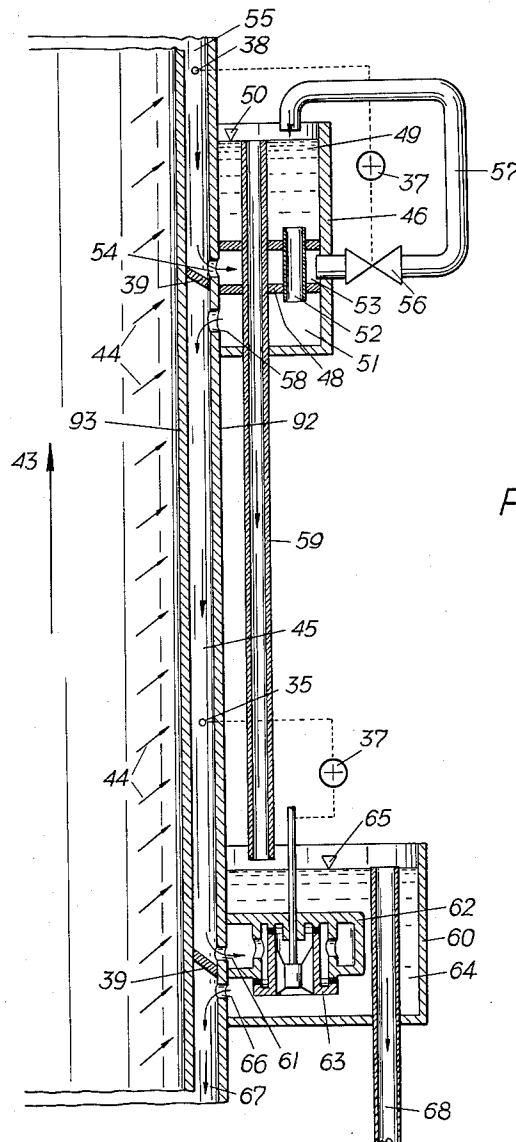


FIG. 10

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3,212,476

## METHOD OF AND APPARATUS FOR COOLING INDUSTRIAL FURNACE INSTALLATIONS

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Filed June 11, 1962, Ser. No. 201,587

Claims priority, application Austria, July 24, 1961,

A 5,697/61

13 Claims. (Cl. 122—7)

The present invention relates to a method of and an arrangement for cooling industrial furnace installations, in particular converter stacks, the cooling medium (water) being allowed to flow under the action of gravity.

It is known to cool the waste gases resulting from metallurgical processes, in particular those issuing from oxygen-blown steel converters, after their exit from the converter and thereafter to rid them of solid dust particles. The cooling of these waste gases which, in oxygen blown converters, have temperatures from 1600 to 1800° C. at the converter mouth, may be effected in various ways. A direct water-injection method is known which, however, in view of these high temperatures, is detrimental and develops large volumes of steam. Also known are waste heat boilers by means of which the converter gases are cooled to the temperature level required for removing the dust. Such waste heat boilers are very economical, since they utilise the heat contained in the gases for generating steam, but their prime cost is high.

If cooling water is available in relatively large amounts, it is also possible to bring the gases to the desired temperature purely by means of water cooling. Various constructional forms of cooling-water stacks have become known in some of which the water is pumped through the cooling ducts of the cooling stack at relatively high pressure, while in others the water is circulated with a natural circulation on the principle of hot-water heating. The first-mentioned method has the drawback that the walls of the cooling ducts must be made thick, so that they are in conformity with the pump pressure.

In the water-cooled stacks heretofore constructed, the flow through the cooling surfaces is produced by means of pumps. In order to overcome any resistance, it is therefore necessary to provide for a high final pump pressure and, consequently, also for a high consumption of power in order to produce a flow at sufficient velocity through the cooling surfaces. In several cases, however, it has proved to be a great disadvantage that, in particular where the heat produced fluctuates and varies locally or where there is fouling, it has not been possible to achieve a good capacity for adjustment, i.e., adaptation of the velocity of the cooling medium, in the individual sections of the stack. For this purpose, it would have been necessary so to increase the final pump pressure for the entire amount of cooling water that the water velocities in the cooling elements subjected to the maximum load can be increased to such extent as is necessary to prevent exceeding a critical limit temperature, for example that of precipitation of the salts causing hardness, or at least the evaporation temperature. To this end it would have been necessary to increase the final pump pressure to three or four times the value at average flow velocity and therefore to provide for a substantially greater consumption of power. Attempts have been made to achieve con-

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trollability of the velocity of the cooling media by providing shut-off devices or regulating devices in the less strongly stressed sections and throttling the flow in these sections, in the expectation that the velocity would therefore increase in the other sections. However, this is possible only to a very limited extent, since with the rise in the velocity in the other sections, the pressure drop in these sections also increases and hence a higher final pump pressure and consumption of power would be necessary. The cooling surfaces are exposed to the full final pump pressure.

Because of the high temperature of the waste gases the second constructional form does not ensure complete freedom from steam in the cooling-water circulation system. If there is local formation of steam, however, there is always the danger of a local increase in pressure and hence of damage to the cooling walls.

It is, therefore, one object of the present invention to provide a method of and an arrangement for cooling industrial furnace installations, in particular converter stacks, wherein the stack has the sole function of cooling down the issuing waste gases or combustible gases rapidly without producing steam.

It is another object of the present invention to provide a method of cooling industrial furnace installations, in particular converter stacks, which method is based upon a completely novel principle according to which controllability of the individual sections can be obtained without increasing the pumping capacity.

It is still another object of the present invention to provide a method of cooling industrial furnace installations, in particular converter stacks, wherein the controllability of the individual sections is achieved in that the cooling medium is conveyed within the walls to be cooled, more particularly in the walls of the converter stack, in closed ducts or passages in the direction of the force of gravity. The cooling water pump merely pumps the water into a high-level or gravity reservoir provided with a level-regulating means which controls a regulating valve connected to the outlet side of the pump. The water flows out of the high-level reservoir solely as a result of gravity, that is downwardly, through the cooling passages which are preferably subdivided into sections, so that by adjusting the outflow cross-section, for example by means of a manually controlled regulating valve or a regulating valve which is automatically temperature-controlled, or else by means of an ordinary manually operated shut-off valve, it is possible to adjust in the individual sections a velocity variable according to the amount of heat present, i.e., according to the temperature at the end of the section, without having to increase the pumping capacity, if the pumping capacity is planned in accordance with the heat output, which, however, is not distributed uniformly over the cooling surfaces. Hence, the outlet temperature of the cooling water cannot exceed a precalculated maximum in the individual sections.

It is another object of the present invention to provide a method of cooling industrial furnace installations, in particular converter stacks, wherein it is possible to obtain a greater velocity of the cooling medium in any desired section, when there is a higher amount of heat present, and conversely. If the cooling medium, for example in one section, reaches a higher outlet temperature than 70° C., for instance, irrespective of the cause, the tempera-

ture impulse controls the outlet valve, so that it is set at "open." If the opposite case occurs, i.e., the temperature is below the fixed outlet temperature, the temperature impulse would control the outlet valve, so that it is set at "shut." In this way the allocation of the correct amount of water to the individual sections is obtained fully automatically, a reduction in the total heat being naturally also followed automatically by way of the level regulator by a reduction in the required average through-flow and feed quantity. The essential advantage of this method is that very high velocities can be obtained in some sections and at the same time lower velocities in the other sections without any consumption of power for increasing the velocity, since said velocity depends solely on the static head, the resistances and the outlet orifice.

In the circumstances obtaining heretofore, that is in which the pump has to pump the water through the heating surfaces, any increase in velocity naturally has the effect of an increase in the pumping capacity, whereas according to the method of the present invention any increase in velocity in the individual sections can occur quite independently of the pumping capacity. Since, in such cooling systems, the outlet temperature of the cooling water is usually fixed at about 70 to 80° C., a completely self-supporting construction without any insulation is possible. In the case of tube systems the tube surfaces may be rigid hooped surfaces. In the case of a double jacket the double jacket is simultaneously a supporting structure and a cooling-heating surface. The system is exceptionally simple and robust and ensures a substantially greater reliability as regards variations in the amount of heat and a simultaneous reduction in operating costs owing to a lower consumption of power. A substantial advantage is also obtained as regards design in that where feed by pump is used, i.e., where the desired velocity is achieved by the feed pressure of a pump, the heating surfaces are loaded by the full final pump pressure, i.e., they attain nominal pressures of the order of magnitude of about 10 atmospheres, whereas in the method according to the present invention only the static height or head determines the pressure in the heating surfaces, it being possible to achieve by structural means the result that not the full static head, but the static head of the individual segments takes effect segment-wise as internal pressure or external pressure on the outer jacket or inner jacket.

The method of the present invention is accordingly particularly advantageous for double-jacket type stacks. In stacks having tubular heating surfaces this advantage does not have such a great effect since, whether the flow is produced by pumps or by gravity, the tubes must necessarily have a minimum wall thickness which will withstand the internal pressure even when there is a pressure increase. However, since in large installations such cooling stacks may reach heights of 25 to 35 meters, the walls of the cooling ducts must still be calculated for a pressure of 3 to 4 atmospheres. With a view to achieving as simple a construction as possible, it is customary to make the cooling stack of circular cylindrical form and to provide it with a double jacket through which the cooling medium flows. With such a construction, however, considerable wall thicknesses already result for a pressure of 3 to 4 atmospheres, in particular in the case of the inner jacket which is subjected to external pressure.

It is therefore, a further object of the present invention to provide an arrangement for cooling industrial furnace installations, in particular converter stacks, wherein the pressure on the inner jacket of a cooling stack of the double jacket type is reduced and furthermore the stack is so designed that the sum of the stresses occurring therein owing to the pressure of the liquid becomes as small as possible. It is known that cylindrical vessels subjected to external pressure must have a greater wall thickness than when they are subjected to equal internal pressure. It is therefore, yet another object of the present inven-

tion to provide an arrangement for cooling industrial furnace installations, in particular converter stacks, wherein the inner wall of the double jacket is formed of individual segments which are convex towards the interior of the stack. These segments may be both of circular cylindrical form and elliptical, or may even approximate to a polygonal form.

It is still a further object of the present invention to provide an arrangement for cooling industrial furnace installations, in particular converter stacks, wherein the stack may be divided over its entire height into two or more sections, each of the same being subjected solely to the pressure of the static height of its cooling medium. Thus, if the stack is divided into two sections, the static pressure drops to one half, while if the stack is divided into three sections the pressure drops to one third, etc. It is thus also another object of the present invention to provide an arrangement for cooling industrial furnace installations, in particular converter stacks, wherein the division of the stack into several sections is achieved in such manner that each section is given a free surface of cooling medium. To this end, for example, there may be arranged around the cooling stack at specific intervals annular cooling medium reservoirs having a free liquid level and from which the cooling medium flows through the double walls of the stack due to gravity. It would be possible to supply each of these cooling medium reservoirs continuously with water through its own pump line, so that each cooling section of the stack has its own amount of cooling medium flowing through it. Of course, such an arrangement would have the drawback that this requires a multiple of the amount of water which is required for a cooling stack in which the static height or head is not subdivided.

It is, therefore, yet another object of the present invention to provide an arrangement for cooling industrial furnace installations, in particular converter stacks, wherein the foregoing drawback is avoided by arranging that said amount of cooling medium flows out of the high-level or gravity reservoir, located at the upper end of the stack and supplied continuously with cooling medium by means of a pump, through the cooling jacket of the uppermost section into the next lower annular chamber having a free cooling medium level. Regulation of the amount of cooling medium is advantageously effected on the exit thereof into the lower annular chamber by means of suitable regulating devices. From this annular chamber the cooling medium again flows through the double jacket of the next lower section of the stack to the next lower annular chamber and so on. Thus, one and the same amount of cooling medium flows through the entire height of the stack, the static pressure in the individual cooling sections being reduced correspondingly. The regulating devices at the lower end of each cooling section may, for example, be adjusted manually according to the amounts of heat occurring in the section concerned. However, it is also possible to effect automatic control of these regulating devices in known manner and to choose as impulse, for example, the temperature at the lower end of a particular cooling section, in such manner that when the temperature of the cooling medium rises the regulating device opens, whereby a greater flow of cooling medium in this section and a better removal of heat are obtained.

Of course, it is necessary to maintain the free liquid level as constant as possible both in the high-level reservoir at the upper end of the stack and in the individual annular chambers. It is, therefore, still another object of the present invention to provide an arrangement for cooling industrial furnace installations, in particular converter stacks, wherein the liquid levels can be maintained constant, for example, in that the high level reservoir and the annular chambers are provided with a suitable overflow pipe through which the maximum amount of water supplied can flow off downwardly. Thus, the

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amount of liquid flowing into the annular chamber in question from the section above can be carried off partly through the next lower cooling section and partly through the overflow pipe. At the lower end of the cooling stack, the entire amount of cooling medium may then flow into an outlet channel. The amount of cooling medium can either be circulated with recooling or, if sufficient quantities of cooling medium are available, flow off.

With these and other objects in view, which will become apparent in the following detailed description, the present invention will be clearly understood in connection with the accompanying drawings, in which:

FIG. 1 illustrates schematically an embodiment of a converter stack having a double-walled cooling jacket;

FIG. 2 is a section taken along the lines 2—2 of FIG. 1;

FIG. 3 illustrates a construction similar to that of FIG. 1 having tubular cooling surfaces;

FIGS. 4 and 5 are sections taken along the lines 4—4 of FIG. 3 in the case of a construction of circular cross-section and angular cross-section, respectively;

FIG. 6 illustrates schematically a construction of a converter stack with a closed reservoir and gas-pressure loading;

FIG. 7 is a fragmentary cross-section of one constructional form of the double-walled stack jacket;

FIG. 8 is a fragmentary cross-section of another modified construction of a double-walled stack jacket;

FIG. 9 is a diagrammatic longitudinal section of a cooling stack, which is divided into three cooling sections;

FIG. 10 is a fragmentary longitudinal section, showing by way of example the details of such cooling sections; and

FIG. 11 is a fragmentary section of a modified form of the construction of an annular chamber with an overflow for the cooling medium.

Referring now to the drawings, and in particular to FIGS. 1 and 2, the arrangement for cooling industrial furnace installations, in particular converter stacks, comprises a double-jacket type stack 1 which is divided into vertically disposed sections 2 and provided with a high-level or gravity reservoir 3, open at its top, which has the function of forming a bridging storage vessel in the event of the feed pump breaking down or in the case of a current failure, in order to ensure continuation of operation for a minimum time, i.e. in the case of LD or similar crucibles, for as long as is necessary to change over from the main pump to the reserve pump, or, if there is a complete current failure, to be able to withdraw the lance. The high-level reservoir 3 has a direct outlet 4 into the jacket, a feed pipe 5 and a discharge means 6 for the cooling medium, temperature sensing devices 7 at the lower end of the jacket being indicated which control shut-off devices, i.e. regulating devices 8, through which the cooling medium passes into the discharge channel 6. In the feed pipe 5 is disposed a regulating valve 9, which is level-controlled at 10, and a feed pump 11.

FIGS. 3 to 5 illustrate the constructional possibilities of applying this method in a cooling stack 1 which is lined with tubular heating surfaces 1'. The outlets of a series of three tubes 1' are connected by connecting units 2' for the purpose of controlling jointly the tubes 1' of each series. FIG. 4 discloses such stack 1 of circular cross-section and FIG. 5 such stack 1 of rectangular cross-section.

The embodiment illustrated in FIG. 6 differs from the preceding embodiments in particular in that a closed reservoir 12 is employed in which a constant liquid level is maintained by means of the regulating valve 9. The surface of the liquid not in communication with the atmosphere, but is loaded by a cushion of air or gas 13, the pressure of which is applied by means of a compressor 14 and is adjusted by a regulating means 16. A driving motor 15 is provided for the compressor and an outlet valve 17 is arranged for the air or the gas 13 of the cushion.

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ion. The converter stacks 1 are also equipped with cooling pipes 1<sup>2</sup> and connecting units 2<sup>2</sup>.

FIG. 7 is a cross-section of the double jacket of a cooling stack in the interior 81 of which the hot waste gases flow. The outer jacket 82 is of circular cylindrical shape and forms with the inner jacket 83 and the radial webs 84 the cooling ducts proper 85. The inner jacket 83 consists of a plurality of segments 86 disposed side by side, and with convex surfaces towards the interior 81 of the stack, so as to extend from one web 84 to the neighboring web 84.

FIG. 8 is another modified form of construction, in which the inner jacket 83' is welded directly to the outer jacket 82', like wise of circular cylindrical form, of the stack. The inner jacket 83' consists of individual adjacently disposed segments 87 which, in order to simplify their manufacture, have a polygonal shape formed by the ridges 88'. The outer jacket 82' and these polygonal segments 87' again form ducts 89' for the cooling medium surrounding the interior 81'.

The segments 86 and 87 can be formed individual or a plurality of the segments can be formed integrally as a single member.

FIG. 9 is a longitudinal section through another cooling stack according to the present invention. The hot waste gases leave a converter 89' at the converter mouth 90 and flow into the interior of the cooling stack 91. The latter consists of the outer jacket 92 and the inner jacket 93, both of which may, for example, be constructed in the form shown in FIG. 7 or FIG. 8. At the upper end 94 of the cooling stack there is arranged a high-level or gravity reservoir 95 which is supplied continuously with cooling medium, for example, water, by way of a pipeline 96 by means of a pump (not shown). The cooling medium has a free level 97 in the high-level reservoir 95 and can flow as a result of gravity into the uppermost cooling section 18 of the three cooling sections 18, 25 and 31. At the lower end of the uppermost cooling section 18 there is an annular reservoir 19 into which the cooling medium flows through an orifice 20. This annular reservoir 19 likewise has a free liquid level 21. By way of a regulating device 22 the cooling liquid can flow into an annular chamber 23 disposed below the reservoir 19 and through an orifice 24 into the middle cooling section 25. The cooling liquid leaves the latter through an orifice 26 and passes into an annular reservoir 27 having a free liquid level 28. By way of a regulating device 29 the liquid finally flows into a lower annular chamber 30 and from the latter into the lowermost cooling section 31. At the lower end of the latter there is an annular chamber 32 from which the cooling medium flows by way of a regulating device 33 into an annular chamber 34 and from the latter by way of a pipe 35 into a discharge channel 36. The regulating devices 22, 29 and 33 are controlled by means of corresponding control devices 37 by the temperature of the cooling medium at the points 38 in each cooling section. The division of the space between the cooling jackets 92 and 93 into the individual cooling sections 18, 25 and 31 is effected by means of walls 39. The liquid level in the high-level reservoir 95 is maintained constant by means of an overflow pipe 40, the level in the annular reservoir 19 by means of an overflow pipe 41, and the level in the annular reservoir 27 by means of an overflow pipe 42. The overflow pipes 40, 41 and 42 likewise open into the discharge channel 36.

FIG. 10 illustrates the construction of a cooling section in somewhat greater detail. The hot gases flow upwardly in the interior of the stack in the direction of the arrow 43 and give up their heat to the inner jacket 93 of the stack, as indicated by the arrows 44. In the duct formed between the inner jacket 93 and the outer jacket 92 the cooling medium flows downwardly owing to gravity. The duct is divided by means of walls 39 into a plurality of cooling sections 55, 45 and 67 located one above the other. At the upper end of the cooling sec-

tion 45 an annular reservoir 46 is arranged around the stack. The reservoir 46 is subdivided into three parts or chambers 49, 53 and 51 by means of two plates 47 and 48. A free liquid level 50 is adjusted in the top chamber 49. The bottom chamber 51 is connected to the top chamber 49 by a tube 52. The cooling medium flows into the middle chamber 53 through an orifice 54 from the upper cooling section 55. From here the cooling medium flows by way of a regulating valve 56 and pipe 57 into the top chamber 49 of the annular reservoir 46. The cooling medium can flow from the bottom chamber 51 through the orifice 58 into the lower cooling section 45. The level 50 in the annular reservoir 46 is maintained constant by means of an overflow pipe 59. Through the latter the overflow water flows into an annular reservoir 60 disposed therebelow. Automatic regulation of the valve 56 is effected by means of the control device 37 in dependence upon the temperature of the cooling medium at the point 38 in the upper cooling section 55.

At the lower end of the cooling section 45, the cooling medium passes through an orifice 61, for example, into a valve box 62 from which it flows by way of a double-seat valve 63 into a liquid space 64 of an annular reservoir 60, in which a free liquid level 65 is again formed. From the space 64 the cooling medium flows through an orifice 66 into the lower cooling section 67 of the duct. The liquid level 65 is maintained constant by means of an overflow pipe 68.

The structural details of the annular reservoir 60 with the double-seat valve 63 are illustrated in detail in FIG. 11. The same references apply as in FIG. 10. From the cooling section 45 of the duct the cooling medium flows by way of the orifice 61 into an annular space 69 of the valve box 62. The latter separates the contents of the annular reservoir 60 into an upper portion 70 and a lower portion 71, which are in communication with one another by way of one or more tubes 72. The double-seat valve 63 bears in its closed position against valve packings 74 and 75 and therefore separates the annular space 69 from the spaces 70 and 71. The double-seat valve 63 is guided by means of a valve stem 76 in a sleeve 77 which, in turn, is connected to a flange 78 which is tightly attached to the valve box 62. When the double-seat valve 63 is open, the cooling liquid can flow out of the annular space 69 into the space 71 disposed therebelow and thence through the orifice 66 into the lower cooling section 67 of the duct. The liquid level 65 is maintained constant by means of the overflow pipe 68 leading to the annular space of the next lower cooling section.

It should be mentioned that the concept of the present invention is not limited to the constructional forms described and shown above. Thus, for instance, the regulation of the flow of the cooling medium could also be effected by means of slides, flaps or other regulating devices. There is also the possibility of providing each of the adjacently disposed cooling ducts 85 (see FIGS. 7 and 8) with its own regulating means for the flow of cooling medium in each section. Having regard to the cost of such a regulating system, however, it may also be expedient to combine a plurality of adjacently disposed cooling ducts 85 to form a regulating unit. In any case, the annular reservoirs arranged around the cooling stack (for example 46 and 60 in FIG. 10) are also divided by means of suitable partition walls into as many sectors as there are regulating units provided at the periphery of the stack.

While we have disclosed several embodiments of the present invention, it is to be understood that these embodiments are given by example only and not in a limiting sense, the scope of the present invention being determined by the objects and the claims.

We claim:

1. A method of cooling industrial furnace installations, in particular converter stacks, including a reservoir on

top of said stacks and a cooling jacket surrounding the latter, comprising

feeding a plurality of vertical streams of cooling medium from at least said reservoir through said cooling jacket by its own gravity along walls to be cooled, controlling the rate of flow of said vertical streams individually in response to the heat encountered in each of said individual streams, measuring the heat in each of said vertical streams, and said step of controlling being responsive to said step of measuring said heat,

2. The method, as set forth in claim 1, wherein said step of controlling the rate of flow of said vertical streams is responsive to the step of measuring the temperature of said cooling medium at a predetermined distance upstream of the outlet of each of said streams.

3. The method, as set forth in claim 1, which includes the step of

maintaining said reservoir of said cooling medium at a substantially constant level for each of said streams.

4. The method, as set forth in claim 1, which includes the step of

dividing each of said vertical streams into a plurality of part streams disposed on top of each other to flow from a reservoir for each of said part streams, thereby reducing the static pressure of said cooling medium upon walls to be cooled.

5. The method, as set forth in claim 4, which includes the step of

subjecting each of said reservoirs for the corresponding of said part streams to atmospheric pressure, and maintaining at a constant level each of said reservoirs.

6. An arrangement for cooling industrial furnace installations, in particular converter stacks, comprising a plurality of vertical sections forming jointly an industrial furnace stack,

each of said sections having an inner wall and an outer wall to form a jacket between said walls, said inner walls forming radiant heat surfaces to be cooled by vertical streams of a cooling medium flowing through said sections,

a reservoir provided at the upper end of each of said sections,

a feeding pump operatively connected with the uppermost of said reservoirs to feed said cooling medium into said uppermost of said reservoirs,

each of said jackets being divided into at least one upper and one lower section, and

means controlling the entrance of said cooling medium in each of said sections in response to the heat encountered in said section upstream relative to each of said sections.

7. The arrangement, as set forth in claim 6, wherein said inner walls of said jackets comprise segments convex towards the inside of said industrial furnace, and said segments of said jackets are of polygonal configuration.

8. The arrangement, as set forth in claim 7, wherein a plurality of said segments are formed integrally as a single member.

9. The arrangement, as set forth in claim 6, which includes

an overflow pipe extending downwardly from a predetermined level in each of said reservoirs, in order to control the level of said cooling medium in each of said reservoirs.

10. The arrangement, as set forth in claim 6, which includes

a collecting pipe disposed at the bottom of said furnace installation and receiving the lower end of each of said overflow pipes.

11. The arrangement, as set forth in claim 6, wherein each of said overflow pipes terminates at its lower end in said reservoir of the adjacent lower section.

12. The arrangement, as set forth in claim 6, wherein each of said vertical sections is divided into a plurality of adjacent annular segments, and means for controlling the rate of flow of said cooling medium at least in each of said segments.

13. The arrangement, as set forth in claim 12, wherein said means for controlling the rate of flow of said cooling medium are coordinated to a group of said segments.

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