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Hollyer

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[54] **APPARATUS FOR THE QUENCHING OF PIPE**

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[51] **Int. Cl.** **C21d 1/62**

[58] **Field of Search** .... 134/166 C, 167 C, 168 C, 134/169 C; 266/4 R, 4 S, 4 E; 148/143, 144

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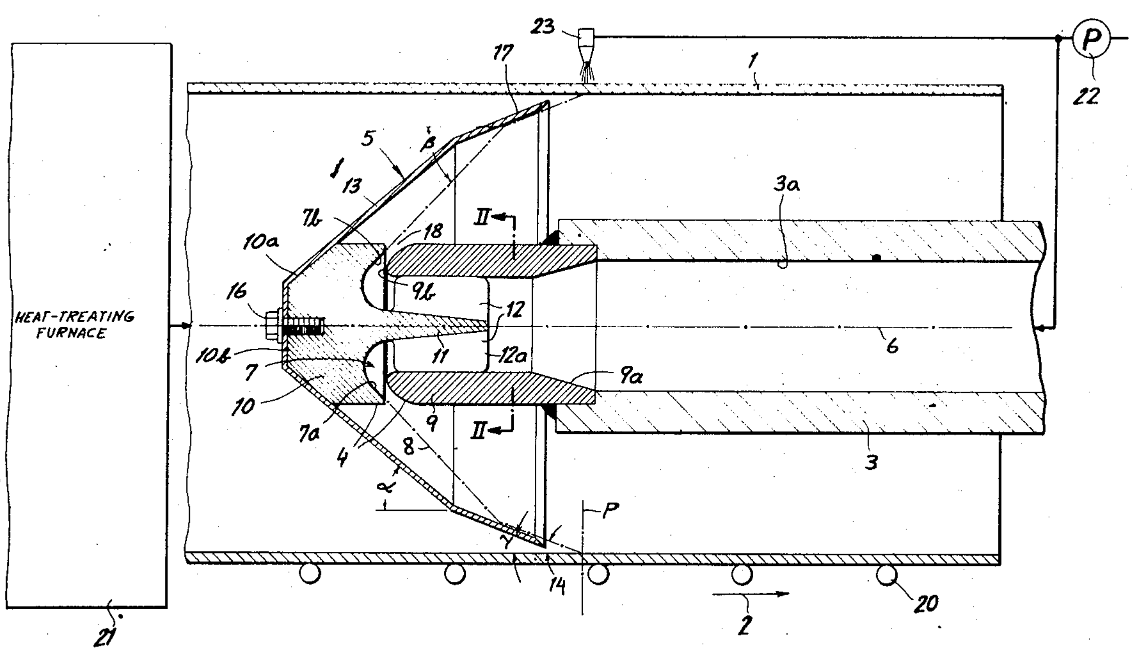
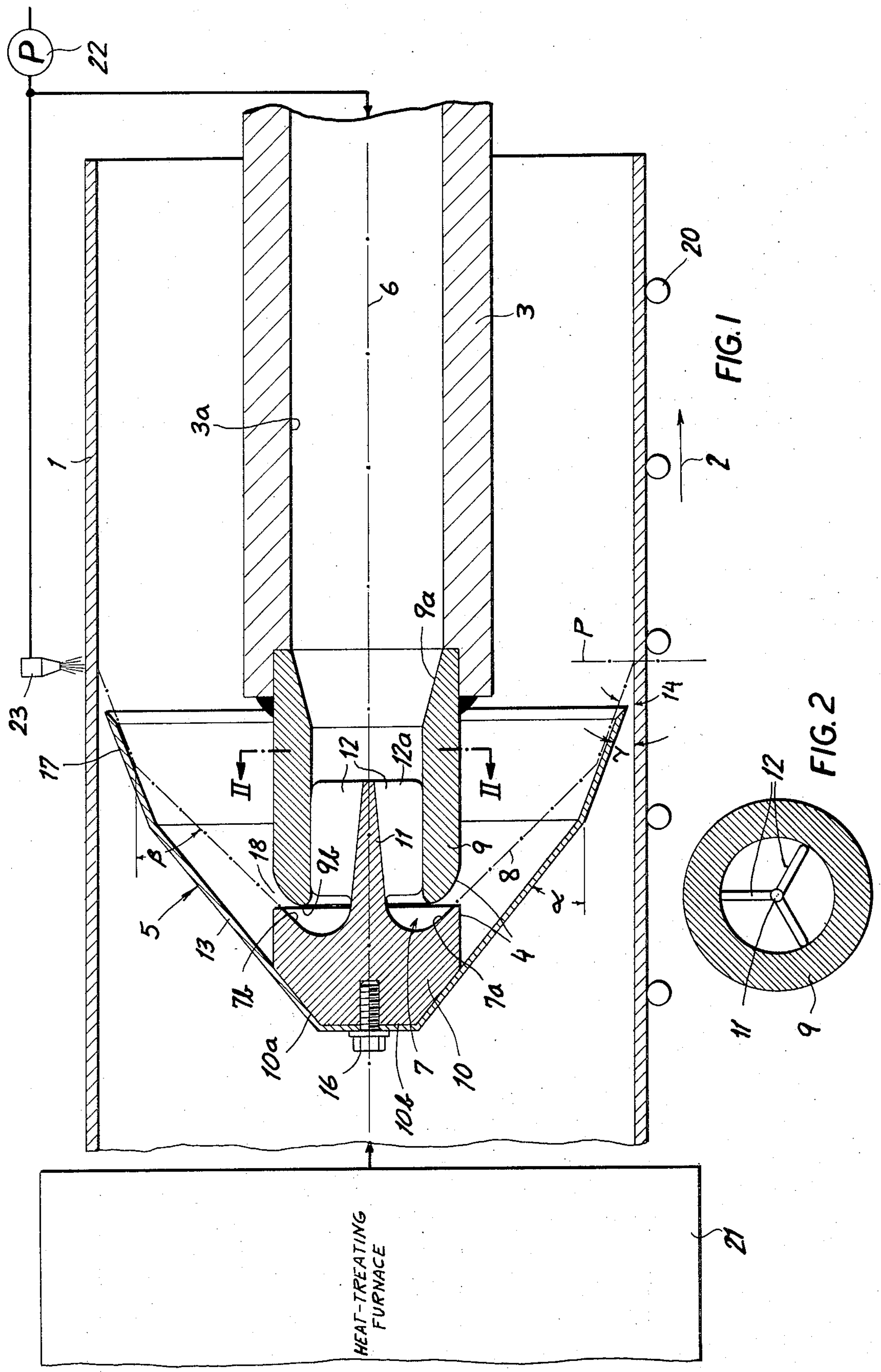
[57] **ABSTRACT**

An apparatus for the internal quenching of pipe comprises a duct extending into the pipe and terminating in a liquid-distribution head forming an annular jet or curtain of liquid directed at the inner wall of the pipe. The jet is deflected along the wall by a shroud coaxially surrounding the head.

7 Claims, 2 Drawing Figures

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HEAT-TREATING FURNACE

FIG. 1

FIG. 2

APPARATUS FOR THE QUENCHING OF PIPE

FIELD OF THE INVENTION

The present invention relates to an apparatus for the quenching of pipe and, more particularly, to a device for the internal quenching of tube, pipe and like elongated hollow bodies.

BACKGROUND OF THE INVENTION

It has already been proposed to quench steel or steel-alloy pipes, tubes and hollow bodies by immersing the heat-treated body in a quenching liquid. When the hollow body is a low-alloy steel pipe of relatively large diameter, immersion is difficult or inconvenient and it has been found to be necessary to externally quench the body by directing jets of water or other liquid quenching medium thereagainst. Quenching has the advantage that the low-alloy steel body can be brought from an austenitic structure to a harder crystalline or grain structure by rapidly cooling the heated body.

A typical apparatus for the quenching of large-diameter pipe may include a ring of nozzles through which the pipe is passed, the nozzles dispensing generally radial jets of the quenching medium against the pipe. The apparatus is displaced axially relative to the pipe by movement either of the pipe or of the nozzle assembly. External quenching is not, however, fully satisfactory for many purposes. For example, the high velocity streams of liquid are often reflected rapidly so that the liquid is not in contact with the external surface of the pipe for the somewhat extended period which is required for rapid heat removal. Attempts to overcome this disadvantage by increasing the pressure or volume of the jet merely increase the cost of the equipment without a concomitant increase in cooling rate or efficiency. Furthermore, external cooling may not provide the desired structure along the interior of the pipe which is cooled less rapidly.

For the purposes of the present invention, the term "pipe" will be used to designate any elongated hollow body preferably of a cylindrical configuration and the term "quenching" to designated rapid cooling of such hollow elongated body, preferably after it has been heat-treated in a suitable furnace or kiln.

In general, considerable effort has gone into developing systems for the rapid quenching of elongated hollow bodies, especially low-alloy steel pipe, after the latter has been brought to an elevated temperature in the range of 800° to 900°C or higher. The pipe or hollow body may be formed by longitudinal or helical seam welding, by drawing, by rotational, centrifugal or core casting or by any of the other methods commonly in use for producing the elongated low-alloy steel bodies described above.

OBJECTS OF THE INVENTION

It is the principal object of the present invention to provide an improved apparatus for the quenching of elongated hollow bodies and preferably hollow bodies such as pipe composed of low-alloy steel.

It is another object of the invention to provide an apparatus for the quenching of heat-treated steel pipe which will avoid the disadvantage of earlier systems as described above.

It is also another object of the invention to provide an apparatus for the quenching of steel pipe and the like which will provide a more uniform, hardened internal (grain or crystalline) structure and which will also eliminate disadvantages of immersion type quenching.

Yet another object of the invention is to provide an apparatus for the rapid quenching of heat-treated steel pipe and the like which will permit greater transfer of heat from the pipe to the quenching liquid, usually water, than has been possible heretofore.

SUMMARY OF THE INVENTION

These objects and others which will become more apparent hereinafter are attained according to the invention, with an apparatus which forms a substantially uniform annular outwardly spreading curtain of the liquid quenching medium along the interior of the heat-treated low-alloy steel pipe at a small acute angle to the internal wall.

More particularly, the invention resides in relatively displacing a heat-treated pipe at an elevated temperature and water-distributing head provided with an annular outlet directed at an angle against the pipe, the acute angle being included between the water curtain and the internal pipe wall in the direction of movement of the pipe wall relative to the head, the vortex of the angle being turned in the direction of movement of the liquid curtain. The pipe, preferably at a temperature of about 800°C, is advantageously displaced while the water-dispensing head is stationary.

According to an important feature of the invention, the water-dispensing apparatus comprises the following essential elements:

a. a water-supply duct extending axially into the pipe and coaxial with the internal, preferably cylindrical surface thereof;

b. a water-distributing head carried by said duct at a free end thereof within the pipe and coaxial with the latter while being provided with a discharge opening which is annular and trained at an acute angle to the internal wall of the pipe; and

c. a shroud surrounding the distribution head and disposed coaxially therewith and with the pipe for intercepting the outwardly dispensed curtain of the head and deflecting it at a somewhat lesser acute angle against the wall of the pipe so that the deflected portion of the curtain forms an obtuse angle with the inner portion of the curtain originating at the distribution head.

The distribution head advantageously is provided with a rotational symmetrical water-deflecting surface which is symmetrical about the axis of the head, the duct, the shroud and the pipe and which is disposed within the path of the liquid traversing the duct. This deflection surface can have inner and outer flanks smoothly immersing with one another through an arcuate annular portion of the head, the outer flanks defining the initial angle at which the inner portion of the curtain is directed against the wall of the pipe.

The distribution head may include a generally cylindrical sleeve portion mounted on the end of the duct ane preferably projecting axially therebeyond while carrying, a head of the internal bore of the sleeve, a deflecting surface of the type described. The deflecting surface may be provided on a boss connected to the sleeve by a water-distributing vane arrangement so that an undivided (continuous) annular gap is formed between the deflector and the mass of the sleeve.

The shroud, preferably constituted from drawn or sheet metal or a synthetic resin, is advantageously of frustoconical configuration and is fixed by its apex to the deflector of the head, e.g., by axially extending screw or bolt. The curtain of water ejected by the head thus has a frustoconical configuration which may be of the same apex angle as the apex angle of the shroud at the point at which the latter is connected to the head, or a different apex angle, preferably selected such that the apex angle of the shroud is less than the apex angle of the inner portion of the curtain. The large-diameter base of the frustoconical shroud may be frustoconical in its own right with a larger apex angle, preferably greater than that of the apex angle of the inner portion of the curtain to intercept the outwardly spreading water curtain and directed along the inner wall of the pipe.

It has been found that this arrangement whereby the angle included between the curtain and the pipe wall at contact is less than 45° and can be as small as 10°, preferably between 20° and 25°, provides a greater duration of contact between the water and the wall of the pipe, reduced reflection, and constantly greater heat transfer to the water.

It has been found that a major problem with dispensing liquids at high pressures against the interior wall of a pipe or like elongated hollow body is that relatively shallow (small) acute angles must be included between the frustoconical curtain of liquid and the cylindrical interior wall if deflection of the liquid with high kinetic energy is not to preclude rapid heat exchange. However, as the angle decreases, the path traveled by the liquid curtain from the head to the wall increases and may be extremely long in the case of large diameter height and small diameter dispensing heads. The liquid curtain becomes unstable over such lengthy paths and develops a flutter or wobble such that portions of the liquid curtain may not contact the wall at all while other portions may contact the wall prematurely. This so-called "flutter" has been found to produce irregularities in the quenching.

Thus an essential feature of the present invention is to provide means for maintaining the free path at the smallest possible distance while nevertheless obtaining the appropriate angle of contact between the liquid curtain and the wall of the pipe. As will be seen below, the optimum angle has been found to be 22° as measured between the wall and the curtain in the direction of movement of the liquid. This relatively small angle requires lengthy free paths when small-diameter dispensing heads are used and pipes having internal diameters ranging between 600 and 2,500 mm (more than 1,000 mm on the average) are treated.

The means enabling the free path to be minimized is constituted by a shroud coaxial with the dispensing head and having an apron reaching in the direction in which the liquid is deflected into the path of the quenching-medium curtain to deflect the latter along the wall of the tube. This shroud may have an inclination to the wall which is equal to the optimum inclination or may even be slightly greater than the optimum of 22°.

According to another feature of the invention, the shroud defines a surface of revolution centered upon the axis of the dispensing head and the supply duct and is located at the free end of the duct upon which the dispensing head is mounted. More specifically, the shroud is affixed axially to a deflecting body forming part of the dispensing head.

According to another feature of the invention, transport means is provided for advancing the pipe in the direction in which the quenching-liquid curtain is projected along the inner wall thereof. The quenching liquid is introduced through the duct in the opposite direction and is deflected by a surface corresponding to a surface of revolution centered on this axis through an angle greater than 90° in the opposite direction and outwardly against the wall. This combination of shroud and dispensing head eliminates practically any backflow of liquid along the tube wall so that quenching occurs substantially instantaneously in the plane of the base of the frustoconical deflected portion of the liquid curtain. The uniformity and reproducibility of the quenching process is found to yield a crystal or grain structure free from the inhomogeneities characterizing earlier systems.

The system of the present invention has been found to be particularly suitable for the quenching of heat-treated pipe with a diameter of 600 to 2,500 mm as indicated when the pressure ahead of the distributor head is 5 to 10 atmospheres (gauge), preferably 7 atmospheres (gauge) and the angle of contact of the liquid curtain, measured in axial section between the wall of the pipe and the liquid curtain is precisely 22°.

DESCRIPTION OF THE DRAWING

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

FIG. **1** is an axial cross-sectional view of a quenching apparatus according to the present invention; and

FIG. **2** is a cross-section taken along the lines II — II of FIG. **1**.

SPECIFIC DESCRIPTION

In FIGS. **1** and **2** there has been illustrated an apparatus for the quenching of low-alloy steel pipe of large diameter, preferably diameters of 1,000 m or more, the steel pipe being represented at **1** and being displaced in the direction of arrow **2** on a transport mechanism such as the roller array **20**. The pipe is withdrawn from the heat-treating furnace **21** which may be of conventional construction and is preferably at a temperature between 800° and 900°C.

In the embodiment of FIGS. **1** and **2**, the pipe is removed while the internal-quenching device is stationary. In some cases, it may be desirable to hold the pipe stationary and shift the quenching device, e.g., by mounting the same on an arm cantilevered from a carriage which is shiftable toward and away from the pipe.

The quenching device comprises a quenching-medium supply duct **3** extending into the pipe so that its axis coincides with the axis **6** of the pipe **1**, i.e., duct **3** and pipe **1** are coaxial. The duct **3** is connected to a pump **22** which delivers water at room temperature (20° to 25°C) at a pressure of 5 to 10 atmospheres (gauge), preferably 7 atmospheres (gauge).

At the free end of the duct **3**, there is provided a distributing head generally designated at **4** and surrounded by a shroud **5**.

The distributor head **4** comprises an inlet sleeve **9** whose mouth frustoconically merges at **9***a* with the inner wall **3***a* of duct **3** and leads to a plurality of passages **12***a* defined between webs, veins or ribs **12** angularly equispaced about the axis **6** and extending readily within the sleeve **9.** The webs **12** form a spider and are joined together at a conically divergent cone **11** which forces the liquid outwardly and guides it onto a deflecting surface, generally represented at **7** to deflect the liquid through an angle in excess of 90° and form a liquid curtain **8** of frustoconical configuration.

The deflecting surface **7** comprises a generally toroidal channel **7***a* axially aligned with the passages **12***a* and spaced from the discharge end **9***b* of sleeve **9.** The toroidal surface **7***a* is tangent to a surface of the divergent cone **11** and is coaxial therewith while beings secured on the axis **6.** Along its outer portion, the rotationally symmetrical deflecting surface **7** comprises a frustoconical surface **7***b* which diverges in the direction of movement **2** of the pipe or in the direction opposite the divergence of cone **11.** The frustoconical surface **7***b* is tangent to the toroidal portion **7***a* and defines an included angle β of the liquid curtain with the wall. This angle β exceeds the angle **14** of the contact cone and may be in excess of 45°, preferably 50° to 55°.

The body **10** of head **4** is carried by the divergent cone **11** and the webs **12** and has a frustoconical seat **10***a* terminating in a small base **10***b* to which the frustoconical inner portion **13** of the shroud **5** is affixed by a screw **16.** The inner portion **13** of the sheet metal or plastic shroud **5** includes an angle α with the pipe wall which may between 30° and 45° and, advantageously, is less than the angle β mentioned earlier but greater than the angle **14.**

The broad end of the frustoconical shroud is a frustoconical portion **17** which intercepts the water curtain **8** and may include the angle **14** with the wall of the pipe although the angle γ between the wall of the pipe and this portion of the shroud may be slightly greater than angle **14** which is 22° where the pipe has a diameter of 1,500 mm and the water pressure is 7 atmospheres (gauge).

The water dispensed from the annular outlet **18** between the sleeve **9** and the body **10,** is projected along the curtain **8** until it contacts the shroud portion **17,** whereupon it is deflected onto the inner wall of the tube to quench the latter in a plane P. External nozzles **23** may, of course, also be provided for simultaneous external quenching. The tube, having a wall thickness of 20 mm, was quenched substantially instantaneously from atemperature of 875°C.

I claim:

1. An apparatus for the internal quenching of a hot pipe comprising a quenching-liquid supply duct extending coaxially into said pipe and displaceable axially relatively thereto; a distributing head mounted on and communicating with said duct and formed with an outwardly widening guide surface rotationally symmetrical with respect to the axis of said head and said duct for dispensing an outwardly conically diverging curtain of quenching liquid toward the inner surface of said body at a first included angle therewith;

and a curtain-deflecting shroud having an annular frustoconical portion coaxially surrounding said head and positioned to intercept said curtain at a location spaced from said guide surface for deflecting said curtain onto said surface at a smaller included acute angle.

2. The apparatus defined in claim **1** wherein said guide surface intercepts the liquid supplied by said duct and diverts it through at least 90° to form said curtain.

3. The apparatus defined in claim **1,** further comprising a transport device for displacing said pipe, said duct and said head being stationary.

4. The apparatus defined in claim **3** wherein said includes an inlet sleeve mounted on an end of said duct, a body disposed ahead of said sleeve in the direction of flow of the liquid through said duct, angularly equispaced webs received in said sleeve and a cone diverging in the direction of flow of the liquid through said duct connecting said webs to said body for supporting the latter in said sleeve, said deflecting surface comprising a generally toroidal portion disposed axially ahead of said sleeve and merging with the surface of said cone, and a frustoconical surface portion merging with said toroidal portion and outwardly thereof.

5. The apparatus defined in claim **4** wherein said shroud has a central portion axially connected to said body and extending frustoconically outwardly thereof at a relatively large angle of inclination to said wall in the direction of flow of said curtain, said portion of said shroud intercepting said curtain being connected to said inner portion and being inclined to the wall of said pipe at a smaller angle.

6. The apparatus defined in claim **5** wherein said curtain impinges on said wall at an included angle therewith of substantially 20° to 25°.

7. The apparatus defined in claim **6** for a pipe having a diamter of 600 to 2,500 mm wherein the pressure in said duct is 5 to 10 atmospheres (gauge), and said curtain impinges upon said wall at an included angle therewith of 22°.

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