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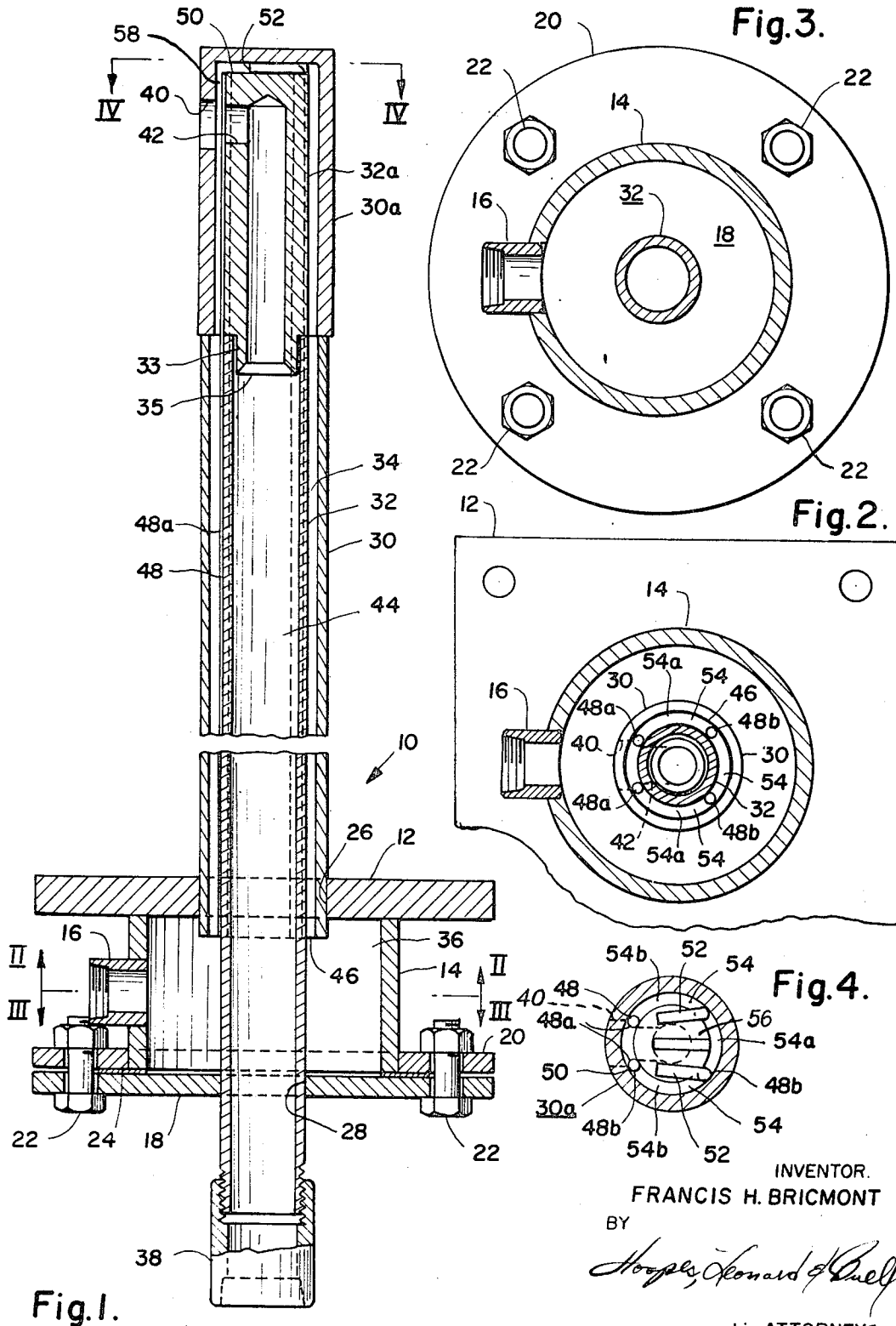


Fig. 1.

Fig. 3.

Fig. 2.

Fig. 4.

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5 Claims

ABSTRACT OF THE DISCLOSURE

There is disclosed a jet structure for use in a high-temperature environment, said structure comprising a pair of spaced elongated interfitting jet tubes, means for spacedly supporting said tubes adjacent their respective ends, at least the other end portions of said tubes being fabricated from a temperature resistant material for insertion into a high-temperature environment, said other end portions having a pair of aligned jet apertures formed respectively therein, and means for introducing a jet fluid into the inner one of said jet tubes for ejection through said apertures. In certain applications, the insertable end portions of the jet tubes are fabricated from relatively heavier walled structural materials. In other applications flow directing means and/or stabilizing means are extending longitudinally through the annular space between the tubes for directing coolant medium through the annular space and in contact with substantially all of the adjacent surfaces of the jet tubes.

The present invention relates to jet structures useful for injecting streams of air and other fluids into furnaces or other apparatus operated at extremely high temperatures. More particularly, the invention relates to jet structures of the character described which can be operated intermittently in such high-temperature environment without undergoing deleterious thermal cycling from the cooling effects of the air or other fluid passing therethrough.

An exemplary application of the present invention, although obviously not limited thereto, is the cleaning of hearth firing troughs of a metal treating or reheating furnace such as is employed in the steel industry. Such hearth firing troughs are described and claimed in a copending and co-assigned application of applicant and Franklin H. Miller entitled, "Hearth Firing Apparatus," Ser. No. 535,763, filed Mar. 21, 1966, and in a copending and partially co-assigned application of Frederick S. Bloom and Rolland L. Hoffman entitled, "Hearth Firing Apparatus," Ser. No. 535,757, filed Mar. 21, 1966, now Patent No. 3,379,423.

In such applications and for use in high-temperature furnaces and other high-temperature environments, it is desirable to install such jet structures permanently within the furnace or other high-temperature locations. However, because of the extremely high temperatures encountered in many furnaces no alloy is presently known which can withstand such temperatures for more than momentary periods of time, without failure from melting, cracking, oxidation or the like. Moreover, where air or other fluid at normal temperatures is to be injected periodically into the high-temperature area in which the jet structure is located, known alloys would be quickly destroyed by the severe thermal cycling occasioned by the intermittent operation of the jet structure. Such thermal cycling occurs, of course, even in those high-temperature environments wherein the temperature is not sufficiently high to destroy the alloy structure of the jet by melting or otherwise.

Previously proposed solutions to these problems involve the use of various insulating or shielding materials, such as plastic alumina, where the jet structures were mounted

permanently in high-temperature areas. Other proposed jet structures utilized an extensible tube which is inserted momentarily into the high-temperature environment during operation of the jet and then retracted. Although these jet structures are satisfactory for many applications, they involve additional fabrication and maintenance expense and the added protective components limited the flexibility of their use or application.

The foregoing problems are overcome by the jet structure disclosed herein, the jet outlet portion of which can be permanently mounted within a high-temperature environment and exposed directly to burner flames or the like without deterioration or undue thermal cycling. In a specific application of the disclosed jet structure, the hottest portion of the jet structure was limited to about 2200° F. with a thermal cycling of less than 1% when installed and intermittently operated in a furnace having a temperature of 2350° F.

A novel jet structure of the invention comprises a pair of nested or interfitting jet tubes which are spaced to provide coolant passages therebetween. A pair of aligned jet apertures are formed in the tubes respectively, and a source of coolant fluid is coupled to the passages between the tubes, while a source of jet fluid is coupled to the inner tube. In other applications of the invention spacing and coolant passage defining means are mounted between the nested jet tubes. In an exemplary application of the invention a coolant fluid at a relatively low pressure is circulated through the aforementioned coolant passages at all times, while the aforementioned jet fluid is introduced intermittently, at longer or shorter spaced intervals as required, through the inner nested tube, which it exits through the aforementioned aligned jet apertures. Where the jet fluid and the coolant fluid are maintained at differing pressures the jet structure is arranged in accordance with another feature of the apparatus to obviate the use of a check valve or the like in the lower pressure system.

In the foregoing general description various objects, features and advantages of the invention have been alluded to. These and other objects, features and advantages of the invention will be elaborated upon during the forthcoming detailed description of the novel jet structure, when taken in conjunction with the accompanying drawings which illustrate certain presently preferred embodiments of the invention together with presently preferred methods of practicing the same.

In the drawings:

FIGURE 1 is a longitudinally sectioned view of one form of jet structure arranged in accordance with the invention;

FIGURE 2 is a cross-sectional view of the jet structure shown in FIGURE 1 and taken along reference line II—II thereof;

FIGURE 3 is another cross-sectional view of the apparatus shown in FIGURE 1 and taken along reference line III—III thereof; and

FIGURE 4 is still another cross-sectional view of the apparatus shown in FIGURE 1 and taken along reference line IV—IV thereof.

With more particular reference to the drawings, the exemplary jet structure 10 illustrated therein includes a mounting plate 12, to the underside of which as viewed in FIGURE 1 of the drawings, is secured hollow cylinder 14 having a fluid inlet 16 and an annular closure plate 18. In the fabrication of the jet structure the cylinder 14 can be welded at its upward extremity to the underside of the mounting plate 12 and at its lower end to a clamping ring 20 whereby the cylinder is secured to the bottom closure 18 by means of bolts 22. A gasket 24 or other suitable sealing member, desirably, is inserted between the bottom closure 18 and the clamping ring 20.

The mounting plate 12 and the cylinder closure 18 in

this arrangement are provided respectively, with aligned generally central apertures 26 and 28 respectively. As better shown in FIGURE 1 of the drawings, the mounting plate aperture 26 is relatively larger than the aperture 28 in order to accommodate an elongated outer jet tube 30 the lower end of which, as viewed in FIGURE 1, protrudes through the mounting plate aperture 26 where it is sealingly welded or otherwise sealed and secured to the mounting plate 12.

On the other hand, an elongated inner jet tube 32, which substantially coextends with the outer jet tube 30 above the mounting plate 12 is interfitted or nested within the outer jet tube 30, by means presently to be described. The inner jet tube 32 thus is spacedly mounted within the outer jet tube 30 to afford annular passage means 34 therebetween. At the lower end of the outer jet tube 30, which preferably terminates within the fluid chamber 36 defined by the hollow cylinder 14, the inner jet tube 32 spacedly protrudes from the outer jet tube 30 and extends downwardly and through the central aperture 28 of the cylinder closure 18. The closure 18 thus forms a support for the inner jet tube 32, which is seal-welded or otherwise sealed and secured to the closure 18 to maintain the integrity of the fluid chamber 36. The secureance of the inner jet tube 32 to the cylinder closure 18 aids in stabilizing the inner jet tube 32 in its upright position relative to the mounting plate 12. In certain applications the secureance of the inner and outer jet tubes 32, 30 in this fashion is sufficient to support the jet tubes depending upon the extent of their cantilevered or free lengths projecting above the mounting plate 12. Where the jet tubes 30 and 32 are relatively longer other means, presently to be described, are utilized to aid in stabilizing the jet tubes 30, 32.

Adjacent the lower inner jet tube, as viewed in FIGURE 1 of the drawings, the inner jet tube protrudes downwardly and outwardly of the air cylinder 14 where it can be threaded or otherwise secured to a suitable coupling 38 or other conduit means utilized for joining the free end of the inner jet tube 32 to a source (not shown) of a suitable jet fluid which exemplarily can be air or waste steam. The inner jet tube 32 thus is segregated from the fluid chamber 36 in its passage therethrough.

Adjacent the upper ends of the jet tubes 30 and 32, each tube is secured to a relatively heavy walled extension 30a or 32a respectively. In order to properly position the jet tube extension 32a on the upper open end of the inner jet tube 32, a necked-down portion 33 is provided on the lower end of the extension 32a and arranged to interfitt closely within the adjacent portion of the jet tube 32. The open end of the necked-down portion 33 desirably is chamfered at 35 in order to reduce fluid friction when jet fluid is passed through the inner jet tube 32.

A pair of aligned jet apertures 40 and 42 respectively are formed in the jet tube extensions 30a and 32a to provide egress for the jet fluid supplied to the inner jet tube 32 and flowing along its axial passage 44 from the aforementioned source of the jet fluid. The radially outward direction of the jet stream issuing from the jet apertures 40 and 42 can, of course, be determined by rotational orientation of the mounting plate 12. The jet aperture 40 of the outer jet tube extension 30a is formed with a relatively larger diameter, in the case of round apertures, to minimize frictional interference with the jet fluid issuing from the inner jet aperture 42, but more particularly for reasons discussed presently.

The length of the jet tube extension 30a and 32a usually define the extent to which the jet tubes 30 and 32 are inserted into the furnace for other high temperature environment. In the arrangement, the jet tube extensions 30a and 32a can be fabricated from relatively heavy walled material, as better shown in FIGURE 1 of the drawings, to improve the durability of their structural materials in the high temperature environment. Ordinarily such heavy walled structures could not be employed at elevated temperatures as thermal cycling would result in cracking of the thick wall sections particularly when the

jet structure is operated intermittently with a relatively cooler jet fluid passing through the jet apparatus 10.

However, means are associated with the jet structure disclosed herein for minimizing the thermal cycling to which the jet structure is subjected even when the jet structure is operated intermittently with a jet fluid such as air at room temperature while the jet tube extensions 30a and 32a are inserted into a high-temperature environment such as a furnace operated in the neighborhood of 2350° F. or more.

For such applications, the jet structure can be fabricated from a high-temperature alloy, such as Type 309 stainless steel. It is contemplated, of course, that other suitable structural materials can be employed depending upon the application of the invention. For many applications, where the temperatures are not severely high, adequate insulation is afforded to the outer jet tube 30 by the air space provided by the annular passage 34. This attains where substantially the only problem is thermal cycling which would otherwise be caused by the passage of cooler jet fluid through the inner tube 32, if the latter were in good thermal contact with the outer jet tube 30. The larger outer jet aperture 40 prevents the cooler jet fluid from entering the passage 34 and destroying the insulating properties thereof in those applications wherein the passage is not required to be coupled to a source of coolant fluid, as in lower temperature environments.

At higher temperatures, however, in order positively to cool the jet tubes 30, 32 sufficiently to prevent thermal deterioration thereof in such environments, including minimizing thermal cycling when the jet structures are utilized intermittently, a suitable coolant fluid is flowed through the annular passage means 34 between the jet tubes 30 and 32 and their extensions 30a and 32a. In an exemplary application, the coolant fluid is air at a relatively lower pressure than that of the aforementioned jet fluid source and is admitted to the fluid chamber 36 through the inlet 16 of the cylinder 14. Thence, the coolant fluid enters the lower open end of the outer jet tube 30 and flows upwardly through the annular passages 34 toward the upper ends of the jet tube extensions 30a and 32a where the coolant fluid exits through the outer jet aperture 40. The annular passage 34, of course, communicates with the fluid chamber 36 at its lower annular opening 46 at the lower end of the outer jet tube 30. Desirably, the coolant flow is maintained at all times while the jet tubes 30, 32 or their extensions 30a or 32a are inserted into the high-temperature environment. The coolant flowing through the annular passage 34 not only maintains the annular jet tubes 30, 32 and their extensions at temperatures approximately below their melting point but limits the amount of thermal cycling to which the jet tubes 30 and 32 and particularly their extensions 30a, 32a are subjected when the relatively higher pressure jet fluid is introduced, for example intermittently, into the inner jet tube 32. More particularly, the thermal cycling of the outer jet tube extension 30a is virtually eliminated, being limited to 1% or less. This is a particularly advantageous aspect of the structure inasmuch as the outer jet tube extension 30a can be otherwise completely unprotected when exposed to the extremely high temperatures of the aforementioned furnace and other applications.

The coupling of high and low pressure systems in this manner would ordinarily dictate the use of a check valve or equivalent in the low pressure system to prevent back flow from the jet fluid when it is intermittently or otherwise introduced into the jet structure 10. However, this is obviated in accordance with another feature of the apparatus by the provision of the relatively larger outer jet aperture 40. Such larger aperture permits the jet fluid to expand as it issues from the inner jet aperture 42 with the result that a low pressure or section is created in the area between the jet apertures 40 and 42. Thus, the high and low pressure systems effectively

are decoupled by the smaller and larger jet apertures 42 and 40 respectively.

In order to stabilize the inner and outer jet tubes, 30 and 32 and their extensions 30a and 32a, one against the other and to at least partially define elongated coolant passages extending the length of the annular flow passage 34, suitable spacing and flow defining means are secured between the outer and inner jet tubes 30, 32. The spacing means can be secured to any one of the jet tubes or both and, in this example, as better shown in FIGURES 2 and 4 of the drawings, are secured to the outer surface of the inner jet tube 32 and its extension 32a

As seen from FIGURES 1, 2 and 4, such spacing means are in the form of elongated rods or beads 48, and in an exemplary arrangement of the invention, are spot-welded or otherwise secured along their lengths to the adjacent outer surfaces of the inner jet tube 32 and its extension 32a. As better shown in FIGURES 1 and 4, the front pair of beads 48a, in this example, are co-extensive with the length of the annular flow passage 34 save that they terminate at the top of the inner jet tube extension, as denoted by reference character 50. Desirably the front rods 48a are aligned respectively with diametrically opposed points on the perimeter of the aperture 40 so that a maximum amount of coolant fluid is directed to the top surfaces of the jet tubes, which surfaces are usually exposed to the highest temperatures. The front rods 48a, of course, cannot be more closely spaced as they would obstruct the outer aperture 40. Thus, the coolant stream defined by the space between the front rods 48a passes directly out of the outer aperture 40, while the bulk of the coolant fluid as defined by the remaining spaces among the flow directing rods 48a, 48b is directed almost entirely to the top surfaces of the jet tubes. The remaining rods 48b are likewise co-extensive with the length of the annular flow passage 34 and their upper end portions are bent over the adjacent top surface of the inner jet tube extension 32a to form a number of spacers 52 (FIGURE 4) to space the top of the inner jet tube extension 32a from the adjacent top surface of the outer jet tube extension 30a. Such spacing minimizes the flow of heat from the outer jet tube extension 30a to the inner extension when relatively cooler jet fluid is passed through the latter. Such spacing also affords a continuation of coolant passages 54 defined by the various spacing rods 48. In this arrangement of the invention, four such spacing rods 48 are utilized, although it is to be understood that the number thereof can be varied depending upon the application and particular configuration of the jet structure.

For extremely high temperature application it is particularly desirable to extend the spacing rods 48 to the top of the inner jet tube extension 32a and to provide flow directing means, such as the rod portions 52, across the top of the inner jet tube extension 32a to prevent the coolant fluid particularly from passage 54a from being short circuited directly to the outer jet aperture 40 in the top region of the annular flow passage 34, where cooling of the outer jet tube extension 30a is usually most needed. Desirably, the bent rod portions 52, together with an additional spacing and flow directing rod segment 56, terminate short of the outer periphery of the top surface of the inner jet tube extension 32a to provide adequate egress of the coolant fluid flowing upwardly through passages 54b extending from each rod 48a to the adjacent one of the rods 48b.

After thus being conducted to the top surfaces of the jet tube extensions, through the aforementioned passages 54a and 54b, the coolant fluid issuing therefrom and flowing over the top of the inner jet tube extension 32a then flows downwardly a short distance 58 (FIGURE 1) between the rods 48a to the outer jet aperture 40, where it exits from the annular passage 34. With this arrangement, all of the coolant flowing through the

passages defined by the spacing rods 48 is deflected, with the exception of the coolant fluid flowing between the pair of rods 48a over the top surface of the inner jet tube extension 32a where it contacts and cools the adjacent inner top surface of the outer jet tube extension 30a in order to afford maximum cooling to the outer top surface of the outer jet tube extension 30a, which in many applications is subjected to the highest temperatures imparted to the jet structure 10.

From the foregoing it will be apparent that novel and efficient forms of jet structures have been disclosed herein which are arranged for intermittently or otherwise injecting a relatively cool jet fluid such as air, steam or the like, and which for this purpose can be permanently located within an extremely high-temperature environment without deterioration by melting, excessive oxidation or thermal cycling. While I have shown and described certain presently preferred embodiments of the invention and have illustrated preferred methods of practicing the same, it is to be distinctly understood that the invention is not limited thereto but may be otherwise variously embodied and practiced within the scope of the following claims.

I claim:

1. A jet structure for use in a high-temperature environment, said structure comprising a pair of spaced elongated interfitting jet tubes, means for spacedly supporting said tubes adjacent their respective ends, at least the other end portions of said tubes being fabricated from a temperature resistant material for insertion into a high-temperature environment, said other end portions having a pair of aligned jet apertures formed respectively therein, and means for introducing a jet fluid into the inner one of said jet tubes for ejection through said apertures, the unsupported and inserted end portions of said jet tubes being fabricated from relatively heavier walled structural material, and said jet apertures being formed respectively in said heavy walled structures.

2. A jet structure for use in a high-temperature environment, said structure comprising a pair of spaced elongated interfitting jet tubes, means for spacedly supporting said tubes adjacent their respective ends, at least the other end portions of said tubes being fabricated from a temperature resistant material for insertion into a high-temperature environment, said other end portions having a pair of aligned jet apertures formed respectively therein, means for introducing a jet fluid into the inner one of said jet tubes for ejection through said apertures, means for supplying a coolant fluid to the space between said tubes for egress through said outer jet aperture, coolant flow directing means extending through the space between said tubes and secured to at least one of said tubes, said flow directing means include a plurality of rods extending substantially along the entire length of said annular space and secured to at least one of said tubes.

3. The combination according to claim 2 wherein a pair of said rods are aligned respectively with diametrically opposed points on the perimeter of the outer one of said apertures.

4. A jet structure for use in a high-temperature environment, said structure comprising a pair of spaced elongated interfitting jet tubes, means for spacedly supporting said tubes adjacent their respective ends, at least the other end portions of said tubes being fabricated from a temperature resistant material for insertion into a high-temperature environment, said other end portions having a pair of aligned jet apertures formed respectively therein, means for introducing a jet fluid into the inner one of said jet tubes for ejection through said apertures, means for supplying a coolant fluid to the other space between said tubes for egress through said outer jet aperture, coolant flow directing means extending through the space between said tubes and secured to at least one of said tubes, said aligned jet apertures being

mounted in the side walls respectively of said jet tubes adjacent the closed ends thereof, and spacing means mounted on one of the end portions of said tubes for spacing said end portions, said spacing means communicating with the flow passages defined by said flow directing means to direct coolant flows between said spaced end portions and to said outer jet aperture. 5

5. The combination according to claim 2 wherein said aligned jet apertures are mounted in the side walls respectively of said jet tubes adjacent the closed ends thereof, a pair of adjacent ones of said rods define a coolant passage communicating directly with said outer jet aperture, and at least some of the remainder of said rods are 10

extended over the closed end of said inner tube to space said inner tube end from said outer tube end and to define coolant passages extending therebetween to said outer jet aperture.

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EVERETT W. KIRBY, *Primary Examiner*.

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