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3,531,050

TWO-PHASE HOMOGENIZER

Filed Feb. 10, 1968

2 Sheets-Sheet 1

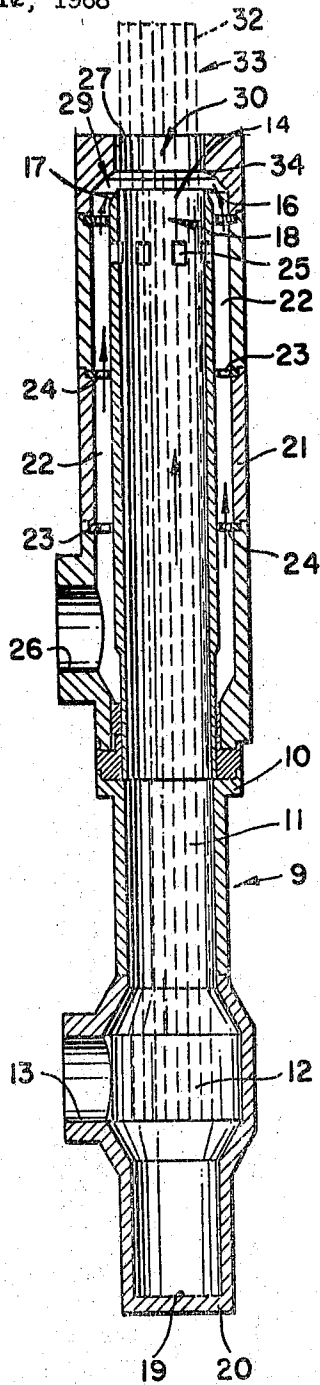


FIG. 1.

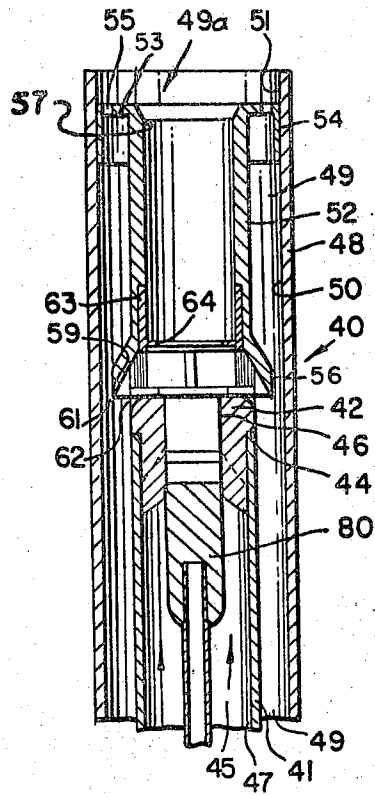


FIG. 2.

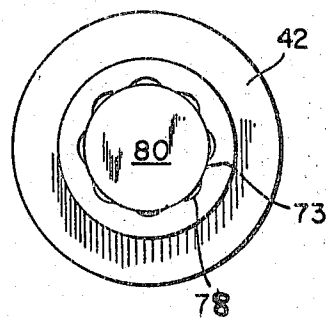


FIG. 4.

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TWO-PHASE HOMOGENIZER

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2 Sheets-Sheet 2

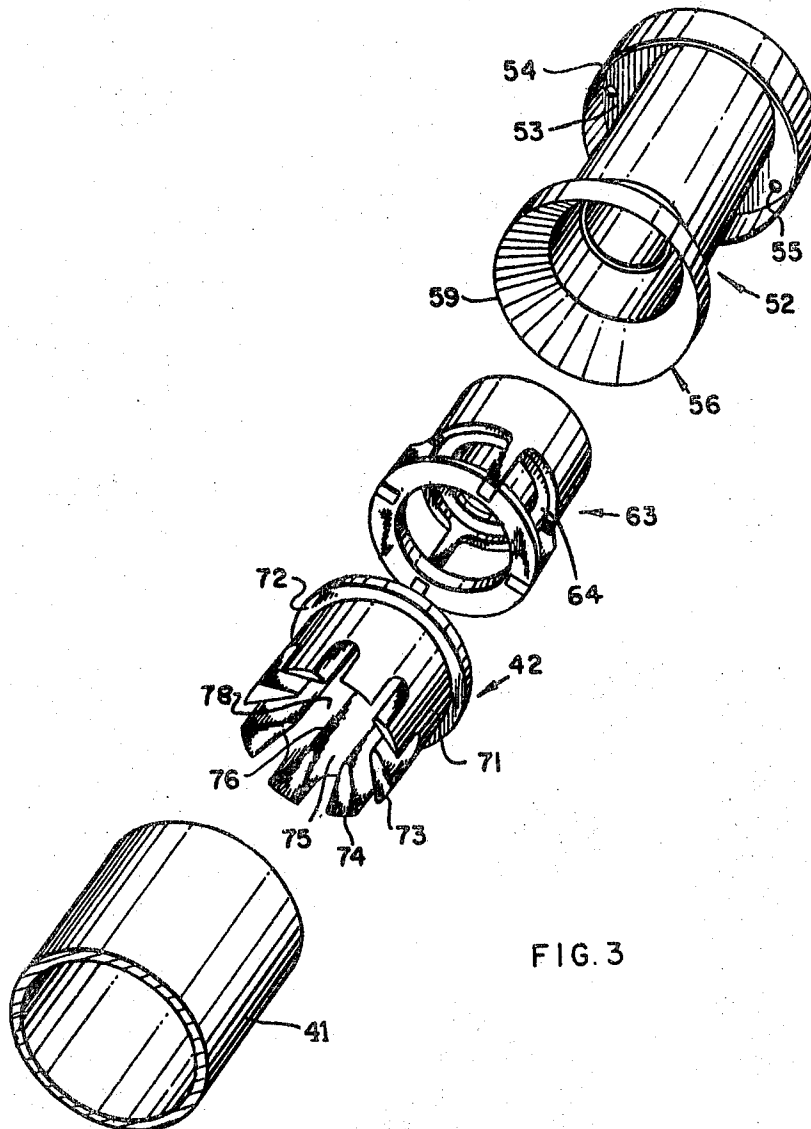


FIG. 3

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TWO-PHASE HOMOGENIZER

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2 Claims

ABSTRACT OF THE DISCLOSURE

A nozzle having inner and outer coaxial tubes, the orifices of tubes coaxial to one another such that mixing takes place at interfaces between the orifices. The resulting mixture is substantially homogeneous and uniform in cross-section.

This invention relates to an apparatus for mixing flows of liquid and gas, particularly steam and water.

Within certain types of atomic reactors, for example, fog cooling reactors, it is desirable to have a coolant stream comprising a homogeneous mixture of water and steam passing over fuel bundles.

The embodiments of the invention achieve a nozzle which will mix a liquid and a gas and in particular water and steam, into a substantially homogeneous two-phase mixture such that the static pressure gradient across the mixture flow is substantially negligible.

The invention therefore contemplates a nozzle for mixing a liquid and a gas into a two-phase homogeneous mixture comprising: an inner conduit for connection with a liquid source, a tubular shroud member spaced downstream from and coaxial with the inner conduit, and outer conduit surrounding the inner conduit and the shroud member and defining an annular chamber therewith for connection with a gas source, a spacing member for spacing the shroud member from the inner conduit, the shroud member having an unstream end and a downstream end, the downstream end terminating in an outwardly extending apertured flange engaged with the outer conduit, the upstream end having a flared flange extending outwardly upstream to direct a portion of a gas flowing in the annular chamber into the shroud member, a nozzle seat disposed in the downstream end of the inner conduit, the nozzle seat having a plurality of skewed channels therein to impart angular momentum to a liquid flowing there-through, and a movable plug positionable with respect to the nozzle seat for controlling the flow of liquid. The spacing member preferably includes a constricting ring for constricting the flow of a fluid through the shroud member.

The invention will now be described by way of example reference being had to the accompanying drawings in which:

FIG. 1 is an elevation in cross-section of one embodiment of the invention;

FIG. 2 is an elevation in cross-section of another embodiment of the invention;

FIG. 3 is a perspective view of the nozzle seat utilized in the embodiment of FIG. 2; and

FIG. 4 is a top view of the nozzle seat and plug shown in FIG. 2.

Referring to FIG. 1 a nozzle 9 includes an inner conduit 10 and has an extended interior 11 and a flow turn chamber 12 disposed therein. A pipe 13 communicates with the chamber 12 to a source of liquid flow (not shown) for example, a water pump. The interior 11 of the conduit 10 terminates at an orifice 14 forming a peripheral

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knife edge 16 such that a bevel 17 slopes towards the outside surface 18 of the conduit 10. The opposite end 19 is closed off as by a plate 20.

Surrounding the conduit 10 is an outer conduit 21 defining a chamber 22 between it and conduit 10. A plurality of spacers 23 restrain the conduit 21 in coaxial alignment with the conduit 10. Each spacer 23 has orifices 24 therein to permit communication throughout the chamber 22 as will be later more clearly understood. A plurality of circumferential slots 25 through the inner conduit 10, in the vicinity of the beveled edge 17, communicate chamber 22 with interior 11. A pipe 26 communicates with chamber 22. The pipe 26 is adapted to be connected to a source of gas pressure (not shown). The outer conduit 21 terminates at an orifice 27 which is coaxial with the orifice 14. The margins of orifices 14 and 27 define coaxially an annular mixing zone 29.

When steam is supplied to pipe 26 and liquid, for example, water, to pipe 13 the liquid and gas flow, following the arrows in FIG. 1, through the interior 11 and chamber 22 respectively. The gas passes partly through slots 25 for partial mixing with the liquid at 18, and partly through 29 which mixes with the aforesaid partially mixed mixture issuing from orifice 14. This mixture issues out orifice 27. This mixing of the liquid and gas phase also takes place in an extended mixing zone 30, in the vicinity of zone 29, such that the fluid phase, downstream from orifice 27, is homogeneous in character and has almost no static pressure gradient at right angles to the flow.

In reality zones 29 and 30 blend into one another such that no clear demarcation between the two can be made. Throughout the extended interior 11, a fuel string 32 (shown in shadow), which consists of a series of coaxially connected fuel bundles can be placed to extend beyond the zone 30 and the orifice 27. The nozzle 9 thereby causes a homogeneous two-phase gas-liquid mixture to flow over the string 32 in the region 33 downflow from zone 30 (and orifice 27) while permitting a pure liquid flow across the fuel string 32 in the interior 11.

Suitable values of the dimensions of the nozzle 9 are given by way of example. The distance between the center of pipe 26 and the base 34 of the orifice 27 is 16.50 inches; the distance between the center of pipe 26 and that of pipe 13 is 15 inches; the diameter of the interior 11 and of the orifice 27 is 3.250 inches.

Referring to FIG. 2 a nozzle 40 includes an inner conduit 41, a nozzle seat 42 in the form of an open-ended tubular member, said seat 42 circumscribing one end 44 of the conduit 41 where the interior 45 of the conduit 41 terminates to form an orifice 46. The other end 47 of the conduit 41 is adapted to be connected to a pressured water supply (not shown) such that water is adapted to flow through the conduit 41 in the direction of the arrow from end 47 to end 44.

The nozzle 40 also includes, exterior to and coaxial with the conduit 41, an outer conduit 48 defining an annular chamber 49 which is adapted to communicate with a supply of steam pressure (not shown). The outer conduit 48 has an inner wall 50 and an outlet end 51, the end 51 disposed downstream from the orifice 46. Coaxially within the outer conduit 48, and downstream from the inner conduit 41, a circumscribing cylindrical shroud 52 is positioned between the end 51 (of the outer conduit 48) and the end 44 (of the inner conduit 41). The tubular shroud member forms an extension of the inner conduit. (See FIGS. 2 and 3.) The shroud 52 which defines, between it and the outer conduit 48, the continuation of the annular chamber 49, has a shroud orifice 57 at one end, which is preferably beveled, and at that end, an outwardly disposed circumferential flange 53, with a

depending margin 54 thereabout. A plurality of serially disposed apertures 55 are drilled through said flange 53. At the other end of shroud 52 is a flare 56 with a tip 59 such that the flare 56 defines with the inner wall 50 (of the outer conduit 48) an outer annular region 61, and with the end 44 (of the conduit 41) an inner annular region 62. An annular spacing member 63 spaces the shroud member 52 coaxially from the inner conduit 41. The spacing member 63 includes a constricting ring 64 that projects radially inwardly at the base of the flare 56 and defines an aperture of smaller diameter than that of the interior of the shroud 52 such that when the spacing members 63 is mounted as by welding in the shroud 52, the shroud 52, the aperture 64, the inner conduit 41 and the outer conduit 48 are coaxial. This relationship is maintained by securing the margin 54, as by welding, to the inner wall 50.

Referring to FIG. 3, the nozzle seat 42 comprises an open-ended tubular member 71 having, at one end, a radially outturned flange 72 and, at the other end, a plurality of circumferential, substantially axially extending (slightly skewed) marginal fingers 73 of substantially triangular cross-section. The fingers 73 have their ends 74 beveled toward the axis of the tubular member 71 as do the semi-circular shaped webs 75 disposed between each finger 73; the apex 76 of each finger 73 is also disposed toward the axis. The profiles of the fingers, and of the webs, blend in such a manner that the webs 75 are a terminus of axially extending channels 78, slightly skewed, within the inner surface of the member 71, adjacent fingers forming the confining walls of the channels 78.

Within the interior of the member 71, a cylindrical plug 80 is axially positionable to control fluid flow running through the interior. When the plug is in full registry (FIG. 4) with the member 71, the channels 78 are restricted in cross-sectional area, but still permit a quantity of flow to pass from the nozzle seat 42 into the region of the flare 56. This is more clearly appreciated from FIG. 2, where the plug 80 is shown in its full open position, the shadow lines illustrating the position of the plug 80 when in full registry with the member 71.

In operation, a liquid, for example water, flows through the inner conduit 41 and out orifice 46. Because of the slight skew of the channels 78, this flow is imparted with small angular momentum which enhances mixing with the gas in the interior of the shroud 52. Gas, for example steam, flows through the annular chamber 49. At the tip 59 (of the flare 56) the steam flow is split into an annular and a core flow path. The core flow path passes into the inner annular region 62 where a first mixing begins to take place with the liquid emanating from orifice 46. The mixing of the gas and liquid continues as the mixture travels through the interior of the shroud 52. Simultaneously therewith, a part of the steam flow is divided by the tip 59 into the annular flow path which passes through the extension of the annular chamber 49 and out orifices 55 into region 49a where a second mixing takes place between the annular flow path gas issuing from orifices 55 and the first mixture of gas and liquid now spouting from the shroud orifice 57. By the time the mixing fluid reaches further downstream a substantially homogeneous two-phase gas-liquid mixture exists.

Examples of satisfactory dimensions for the nozzle 40 are as follows: the gap between the tip 59 and the inner wall 50 (width of the outer annular region 61) is 0.20 inch, while the gap between the tip 59 and the nozzle seat 42 (the width of the inner annular region 62) is 0.375 inch. The inner diameter of the shroud 52 is approximately $1\frac{3}{4}$ inches and the width of the extension of the annular chamber 49 (the gap between the shroud 52 and the inner wall 50) is approximately $\frac{1}{16}$ inch. The aperture 64 has a diameter of about $1\frac{1}{8}$ inches. The ten circumferentially, disposed apertures 55 have a diameter of about

$\frac{3}{16}$ inch. The plug 80 has a diameter of about 1.024 inches and a length in excess of $2\frac{1}{2}$ inches. The channels 78 in the nozzle seat 42 dispose an area of about 0.035 sq. in. when the plug 80 is in registry, while the orifice 46 displays an area of 0.721 square inch when the plug 80 is not in registry (see FIG. 2). The fingers 73, have their ends 74 beveled at an angle of about 53° , while the web 75 is at an angle of about 66° , both angles relative to the axis of the nozzle seat 42. The channels 78 originating at the web 75, and bounded by the fingers 73, are slightly skewed (about 5°). Throughout its length, each channel 78 deviates in successive angular increments, as measured relative to the axis of the nozzle seat. Initially each channel deviates, when coincident with the web 72 at an angle of about 66° , then to an angle of about 14° and finally to an angle of about 83° at which angle the channels intersect and terminate at the outturned flange end of the nozzle seat 42 such that the plurality of channels 78 cooperate to form the orifice 46.

Using the above example dimensions, the velocity of the liquid particles can be maintained constant even when the flow is varied from a minimum of 1 unit mass/unit time (that is approximately 1000 pounds/hour) to a maximum of 10 units mass/unit time (that is 10,000 pounds/hour). This is accomplished by sliding the plug 80 from the full-closed position to the full-open position, that is through a stroke of 1.50 inches. The resulting liquid spray emerges from region 49a with a cone having a small subtended angle in the neighbourhood of 15° .

When the nozzle 40 is used in conjunction with a fog cooling reactor the fuel bundle (not shown) is located downstream from the region 49a about 6 inches.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A nozzle for mixing a liquid and a gas comprising, an inner conduit for connection with a liquid source, a tubular shroud member spaced downstream from and coaxial with said inner conduit, an outer conduit surrounding said inner conduit and said shroud member and defining an annular chamber therewith for connection with a gas source, a spacing member for spacing said shroud member from said inner conduit, said shroud member having an upstream end and a downstream end, said downstream end terminating in an outwardly extending apertured flange engaged with said outer conduit, said upstream end having a flared flange extending outwardly upstream to direct a portion of a gas flowing in said annular chamber into said shroud member, a nozzle seat disposed in the downstream end of said inner conduit, said nozzle seat having a plurality of skewed channels therein to impart angular momentum to a liquid flowing therethrough, and a movable plug positionable with respect to said nozzle seat for controlling the flow of liquid.

2. The nozzle according to claim 1 wherein said spacing member includes a constricting ring for constricting the flow of a fluid through the shroud member.

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