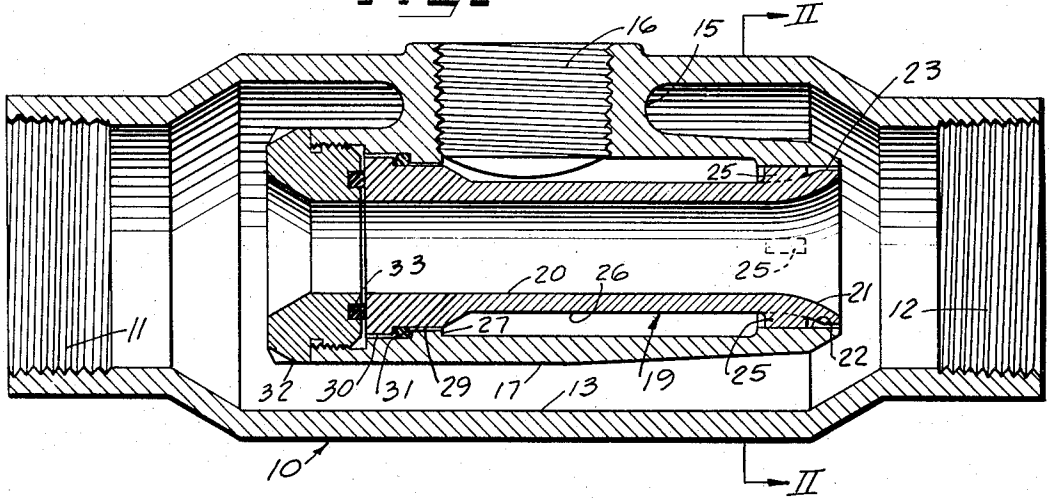
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THIN STREAM DIRECT CONTACT FLUID HEATER

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Fig. 1



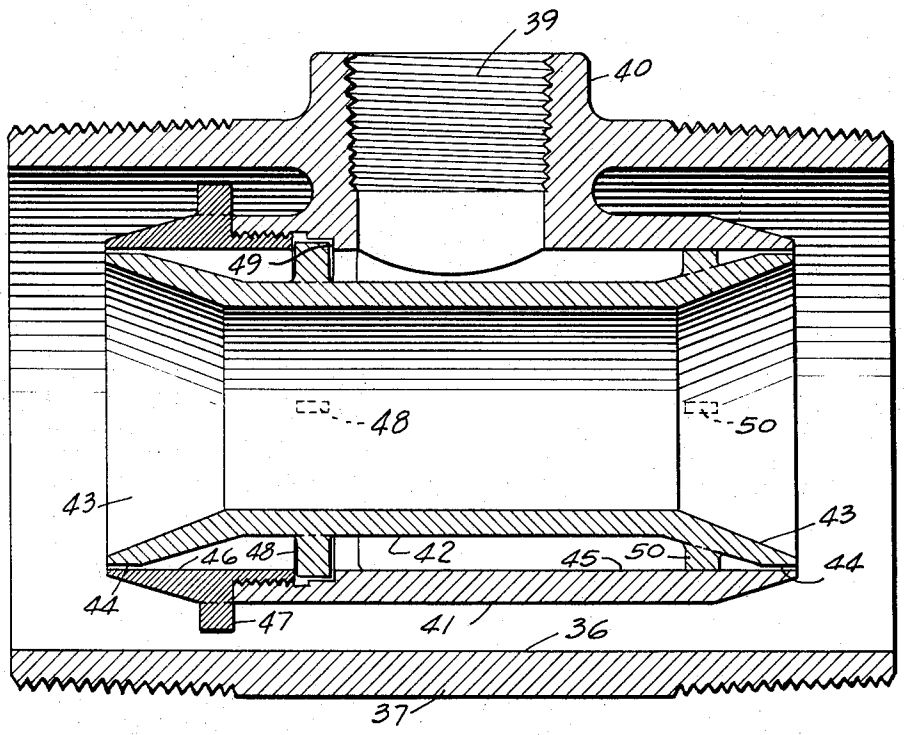




Fig. 3

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THIN STREAM DIRECT CONTACT FLUID HEATER

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Fig. 2

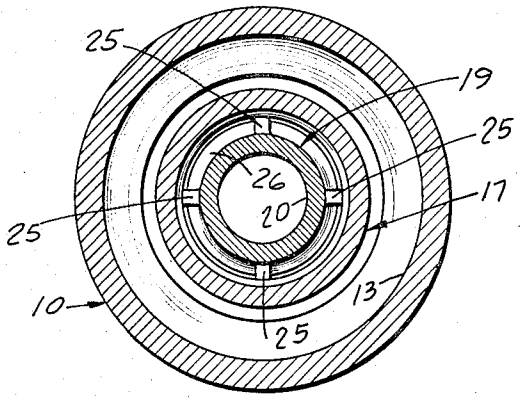
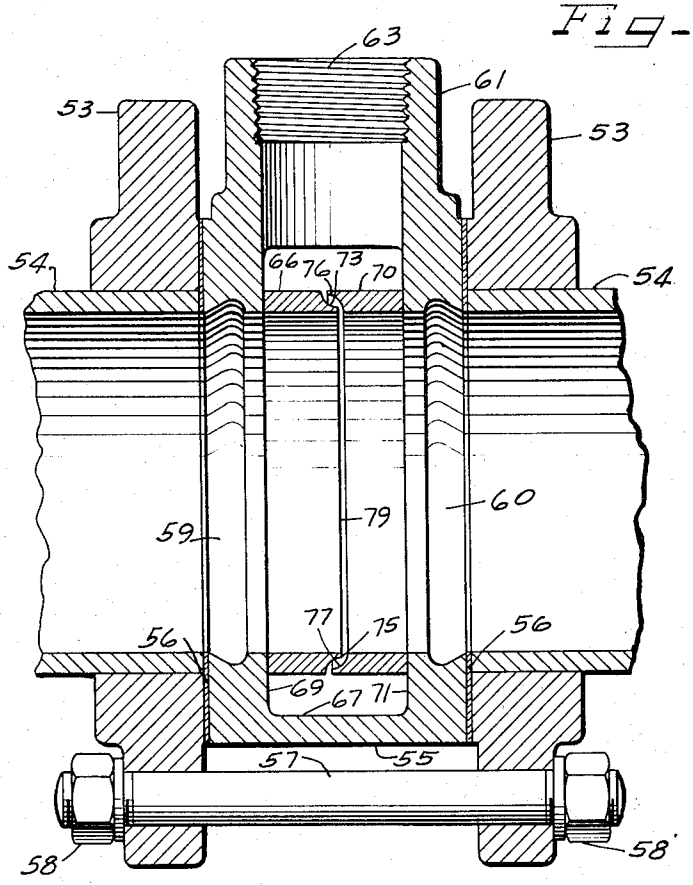



Fig. 6




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THIN STREAM DIRECT CONTACT FLUID HEATER

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Fig. 5

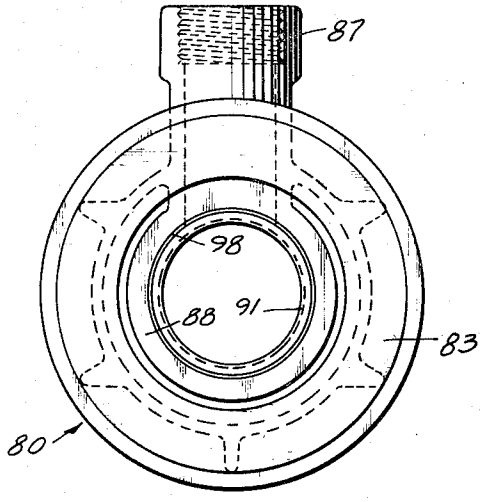
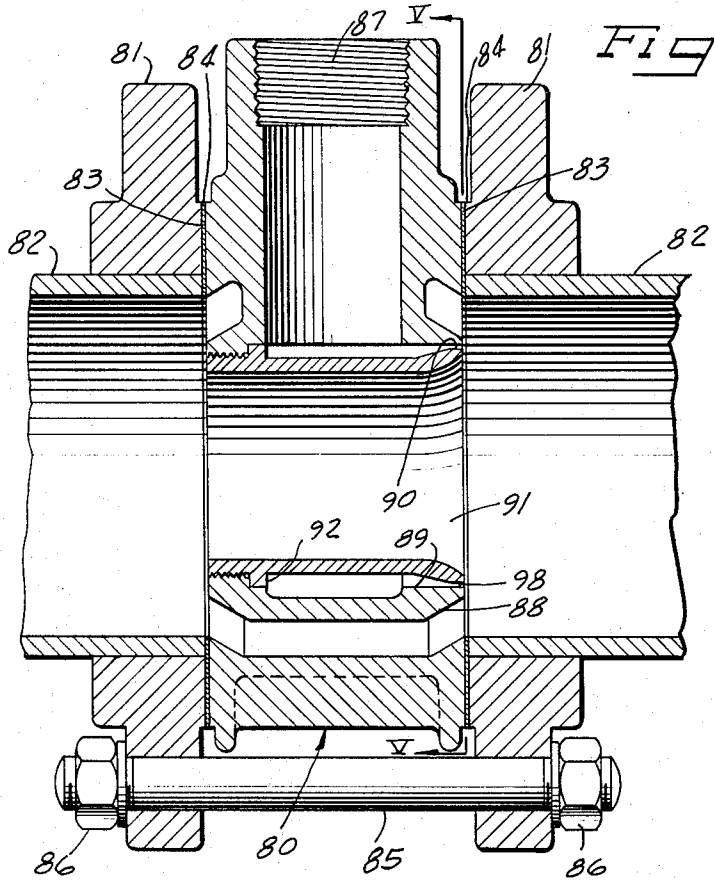



Fig. 4




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3,360,248

# THIN STREAM DIRECT CONTACT FLUID HEATER

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## ABSTRACT OF THE DISCLOSURE

Steam injection-type heater for water in which a thin annular stream of steam is injected into the water in parallel relation with respect to the flow of the water. The heater includes an open ended heater body having a hollow cylindrical nozzle support mounted within the body and spaced from the interior wall of the body and having communication with a source of steam. The nozzle extends along the interior of the support and has an exterior cylindrical end wall cooperating with an interior cylindrical wall of the support, and spaced in fixed predetermined relation with respect to the interior wall of the support to form a thin annular nozzle for the injection of steam into the water flowing through the nozzle and around the outside of the nozzle and support. The nozzle is retained to the support by a hollow nut threaded in the support and spaced from the nozzle, to accommodate limited freedom of movement between the nozzle and the support, to reduce the transmission of vibrations to the heater body. Vibration damping means in the form of an O-ring is interposed between the nut and the upstream end of the nozzle body, to damp vibrations of the nozzle and thereby deaden the sound caused by vibration of the nozzle. In a modified form of the heater, annular orifices are at each end of the support.

### *Summary and objects of the invention*

A principal object of the invention is to provide an improved form of fluid heater, which is particularly adapted for connection in a fluid pipe line, to heat the fluid by the direct contact of a film of steam therewith.

Another object of the invention is to provide a novel and improved form of heater for fluid, such as water, in which the water is heated as it passes along a conduit by steam in the form of a thin ribbon entering and surrounded by the stream of water and flowing in the direction of flow of water along the conduit.

A still further object of the invention is to provide a simple and improved form of heater for water and the like, arranged with a view toward reducing the pressure drop heretofore present in such heaters to substantially zero, by injecting a thin ribbon of steam in the water in the direction of flow thereof and inwardly of the marginal flow portions of the water.

Still another object of the invention is to improve upon the water heaters theretofore in use and reduce the noise and the pressure drop heretofore present, by injecting a thin annular ribbon of steam into the water flowing along a conduit, inwardly of the margin of the conduit, to surround the ribbon of steam with water to be heated.

Still another object of the invention is to provide a novel form of inline water heater in which the surface area to volume of water ratio in contact with the steam is increased by injecting an annular ribbon of steam in the flow conduit for the water, inwardly of the margin of the conduit and flowing parallel to the flow of water through the conduit.

A still further object of the invention is to provide an improved form of water heater having a nozzle assembly supported within the inner wall of a pipe, having oppositely facing nozzle portions injecting thin annular streams of steam in the direction and contra to the direction of flow of the water along the pipe and surrounded by the water passing through the pipe.



A still further object of the invention is to provide a novel and improved form of water heater adapted for insertion directly in a pipe line, in which quietness in operation of the heater unit is attained over a far wider range of operating conditions than has heretofore been considered possible, by injecting a thin ribbon of steam in water flowing through a pipe, inwardly of the margin of the stream and in the general direction of the flow of water through the pipe.

These and other objects of the invention will appear from time to time as the following specification proceeds and with reference to the accompanying drawings wherein:

FIGURE 1 is a longitudinal cross sectional view taken through a fluid heater constructed in accordance with the principles of the present invention;

FIGURE 2 is a transverse sectional view taken substantially along line II—II of FIGURE 1;

FIGURE 3 is a longitudinal sectional view taken through a modified form of fluid heater constructed in accordance with the principles of the present invention;

FIGURE 4 is a longitudinal sectional view of another form of fluid heater embodying the principles of the invention;

FIGURE 5 is an end view of the heater shown in FIGURE 4, with the flanged connectors and communicating pipes removed; and

FIGURE 6 is a cross sectional view taken through still another form of fluid heater incorporating the principles of the present invention.

In the embodiment of the invention illustrated in FIGURES 1 and 2 of the drawings, we have generally shown a heater body **10** having an inlet **11** at one end thereof and axially aligned outlet **12** at the opposite end thereof. The heater body **10** is in the general form of a conduit having an internal cylindrical wall **13** and having a hollow boss **15** extending inwardly of said wall, the hollow portion of which is threaded and forms a steam inlet **16**. The boss **15** forms a support for a nozzle support **17** extending axially of the body **10** and shown as being generally cylindrical in form. The nozzle support **17** forms a support for nozzle **19** extending along the interior thereof and having a generally cylindrical interior wall **20** extending axially of the wall **13** along the center thereof for the flow of fluid therethrough and outwardly flared at its discharge end, as indicated by reference numeral **21**. The nozzle support **17** has a generally cylindrical interior and a reduced diameter interior cylindrical downstream end portion **22** extending about a generally cylindrical exterior wall portion **23** of the nozzle **19** and spaced radially outwardly therefrom a distance sufficient to form with said nozzle an annular orifice through which a thin annular ribbon of steam may issue, for heating the fluid passing along the wall **13** and surrounding the ribbon of steam, as well as heating the fluid passing along the interior wall **20** of the nozzle **19**. Spacer lugs **25, 25** extend radially outwardly of the nozzle **19** upstream of the wall **23**. The lugs **25, 25** engage the internal cylindrical surface **22** of the support **17** and space the wall **23** from the wall **22** the required distance to effect the issue of a thin ribbon of steam through the nozzle formed between the wall portions **22** and **23**.

The nozzle support **17** has an annular rib **27** extending radially inwardly of said wall, upstream of the inlet **16** and conforming to and engaging an enlarged diameter exterior cylindrical wall portion **29** of the nozzle **19**. The

rear end portion of the nozzle has an annular rib or axial flange 30 extending outwardly of the wall portion 29, which with the wall portion 29 forms a shoulder for an O-ring 31, adapted to surround the wall portion 29 and be interposed between the shoulders formed by the annular ribs 27 and 30. A hollow retaining nut 32 is shown as being threaded in the upstream end of the support 17, upstream of the inlet 16 and as having an O-ring 33 seated therein.

The retaining nut 32 serves merely to retain the nozzle in position, but does not clamp the nozzle tight to its support. The nut 32 instead allows some floating movement of the nozzle, and while the O-rings 31 and 33 may act as seals, their primary junction is to isolate vibration and deaden sound.

In operation of the heater, the heater body 10 may have the adjacent ends of pipes (not shown) of a pipe line (not shown) threaded therein through which the fluid to be heated flows. A steam pipe (not shown) may be threaded within the threaded inlet 16 extending along the hollow boss 15 for injecting steam in the annular space formed between the exterior wall 26 of the nozzle 19 and the interior wall of the support 17, to be ejected through the annular orifice formed in the space between the cylindrical walls 22 and 23 into the stream of flowing fluid, inwardly of the wall 13 and outwardly of the center of the stream of flowing fluid, and thereby surrounded by the flowing fluid and surrounding the flowing fluid, to increase the heat transfer from the steam to the fluid, without the objectionable noise and pressure drop heretofore present in direct contact fluid heaters, and particularly heaters of the steam injecting type.

In FIGURE 3 of the drawings we have shown a modified form in which the invention may be embodied operating on principles similar to the form of the invention shown in FIGURE 1 except thin ribbons of steam are injected into the flowing fluid inwardly of a cylindrical wall 36 of a heater body 37 in the direction of flow of fluid through the heater body, and in a direction contra to the direction of flow of fluid through the heater body.

In this form of the invention, a steam inlet 39 leads through a hollow boss 40 leading into the heater body and terminating into a generally cylindrical support 41 for a nozzle 42 spaced inwardly of the interior wall of the support. The outer wall of support 41, like the support 17, is spaced inwardly of the wall 36 of the heater body 37 to accommodate the flow of water thereabout. The interior of the nozzle 42 has opposite outwardly flared end portions 43, 43 surrounded by generally cylindrical outer surfaces 44, 44 of the nozzle, spaced upstream and downstream of the liquid flow. The downstream end cylindrical wall portion 44 cooperates with an interior wall portion 45 of the support 41 to form a thin annular orifice for the issue of an annular ribbon of steam therethrough. The upstream wall portion 44 cooperates with the interior cylindrical wall portion 46 of a retainer 47, threaded within the upstream end of support 41, to form a narrow annular orifice for the issue of steam in the form of a thin ribbon therethrough, in a direction upstream of the flow of water through the nozzle 42. The retainer 47 is threaded within the upstream end of the support 41. Clearance is provided between the inner end of said retainer and spaced spacer lugs 48 extending radially of the outer wall of the nozzle body. Clearance is also provided between said spacer lugs and an annular shoulder 49 extending inwardly of the support 41. This is to accommodate limited free movement of the nozzle 42 to prevent the transmission of vibration to the heater body 37. Spacer lugs 50, 50 serve to space the downstream end of the nozzle from the interior wall 45 of the support 41, to maintain the desired spacing betwen the exterior cylindrical surface 44 and the interior wall portion 45, as in the form of the invention illustrated in FIGURES 1 and 2.

Steam entering the steam inlet 39 will thus pass in the space between the nozzle 42 and interior wall 45 and will be ejected in the form of thin streams parallel to the flow of fluid through the heater body, radially inwardly of the interior wall of the heater body, in directions contra to the flow of fluid through the body and in the direction of flow of fluid through the body, and thus heating the fluid before it passes about the support 41 and through the interior of the nozzle 42 as well as after it leaves the support 41 and nozzle 42.

It should here be understood that in certain conditions more than one heater may be provided in a pipe line where conditions require, as where it is necessary to have a more rapid high temperature rise of the fluid. Where a high temperature rise is required, the heaters may be arranged in series. Where it is required that there be a high flow rate, the heaters may be arranged in parallel. Also, the annular orifice of one heater may face upstream and the annular orifice of a next succeeding heater may face downstream, where two heaters may be arranged in series.

In FIGURES 4 and 5, I have shown a heater body 80 which may be connected between flanges 81, 81 on the adjacent ends of pipes 82, 82 of a pipe line. The heater body has annular sealing faces 83, 83 at opposite ends thereof, adapted to be engaged by gaskets 84, 84 extending about the adjacent ends of the pipes 82, 82 and flanges 81, 81 extending radially therefrom. Studs 85 extending through the flanges 81, 81 and having nuts 86, 86 threaded on opposite ends thereof, draw the flanges and gaskets into sealing engagement with opposite faces 83, 83 of the heater body 80.

In this form of the invention, an inlet 87 enters the body 80 through the wall thereof and terminates into a cylindrical nozzle support 88 having an internal cylindrical wall 89, cooperating with an external cylindrical wall 90 of a nozzle member 91. The nozzle member 91 is like nozzle member 19 and has a shouldered portion 92 near its upstream end. The end portion of the nozzle opposite from the external cylindrical wall is threaded to accommodate threading of the nozzle within the support 88.

The walls 89 and 90 thus form the margins of a thin annular steam orifice 98, forming the steam passing through said orifice into an annular ribbon injected into the water flowing along the inside and outside of the orifice 98, nozzle member 91 and nozzle support 88.

In the form of the invention illustrated in FIGURE 6, we have shown still another form of the invention in which the heater may be connected between adjacent flanged ends 53 of pipes 54 of a pipe line. In this form of the invention, a heater body 55 is sealed to the adjacent flanged ends 53 of the pipe line by gaskets 56 maintained in sealing engagement with the opposite ends of the body 55 by studs 57 extending through the flanges of the flanged ends of the pipes 54 and having nuts 58 threaded thereon, drawing the flanges and gaskets 56 into engagement with opposite ends of the heater body. In this form of the invention, the heater body has an inlet 59 and an axially aligned outlet 60, with a hollow boss 61 extending radially outwardly of the heater body 55 and having a threaded interior wall portion 63 forming an inlet into the heater body.

As shown in FIGURE 4, an annular insert 66 is mounted in the heater body inwardly of an interior wall 67 thereof and abutting an annnular shoulder 69 at the upsteam end of the wall 67 and suitably secured thereto. A similar annular insert or sleeve 70 is arranged coaxially of the insert 66 and abuts a downstream shoulder 71 extending perpendicular to the shoulder 67 and is secured thereto in a suitable manner. The inner edge of the insert 66 has a recessed portion 73 generally arcuate and concave in form and terminating into a thin discharge lip 75.

The upstream edge of the insert 70 has an intake lip 76 terminating into a concave generally arcuate wall portion 77 extending parallel to the lip 75 at the discharge end of the insert and forming a slot or orifice 79 for injecting an annular ribbon of steam into the fluid flowing through the pipes 54, 54 and heater body 55, in angular

relation with respect to the flow of water through the pipes 54, 54, or in off parallel relation with respect to the flow, in contrast to the parallel annular ribbon injected into the flowing stream of fluid in the forms of the invention illustrated in FIGURES 1, 2 and 3.

It should here be understood that when defining the orifice walls as cylindrical, that this is a general form of terminology used for convenience, but that we do not wish to be construed as limiting ourselves to cylindrical wall portions or annular jets of steam and wish it to be understood that the walls of the nozzle and support, as well as the interior wall of the nozzle body may be rectangular, hexagonal, octagonal and of various other desired shapes.

We further wish it to be understood that while we have herein shown and described several forms in which the invention may be embodied, we do not wish to be construed as limiting ourselves to the specific form shown, but wish it to be understood that various other modifications and variations in the invention may be attained without departing from the spirit and scope of the novel concepts thereof.

We claim as our invention:

1. In a direct contact fluid heater,
a heater body,
a fluid inlet into said body through one end thereof,
a fluid outlet from said body through the opposite end thereof,
said body having a generally cylindrical wall between said inlet and said outlet,
a hollow boss extending into said body through the wall thereof and forming a steam inlet,
a hollow cylindrical support in the inner end of said boss and having an exterior wall spaced radially inwardly of the cylindrical wall of said body and a generally interior cylindrical wall having communication with said hollow boss for the passage of steam therealong,
a nozzle extending along said support and having an interior wall portion forming a fluid flow conduit,
an exterior wall portion in communication with the steam inlet and spaced inwardly of the interior wall of said support and with the interior wall of said support forming an annular steam flow passageway,
the exterior wall of said nozzle diverging adjacent the discharge end thereof and terminating into a cylindrical end wall portion parallel with and cooperating with the interior cylindrical wall of said support to form a thin annular orifice,
a hollow nut threaded in the opposite end of said support from said orifice and retaining said nozzle to said support,
said nut being spaced from the end of said nozzle to accommodate limited freedom of movement of said nozzle with respect to said support,
spacer means maintaining a predetermined spacing between the cylindrical end wall portion of said nozzle and the interior cylindrical wall portion of said support in all positions of said nozzle relative to said support,
and vibration damping means interposed between said nut and the upstream end of said nozzle, damping vibration of said nozzle and thereby deadening the sound caused by vibration of said nozzle.

2. A direct contact fluid heater in accordance with claim 1 wherein the vibration damping means comprises an O-ring interposed between said nut and nozzle,
and another O-ring interposed between said nozzle and the interior wall of said support.

3. In a direct contact fluid heater,
a heater body,
a fluid inlet into said body through one end thereof,
a fluid outlet from said body through the opposite end thereof,



said body having a generally cylindrical wall between said inlet and said outlet,
a hollow boss extending into said body through the wall thereof and forming a steam inlet,
a hollow cylindrical support on the inner end of said boss and having an exterior wall spaced radially inwardly of the cylindrical wall of said body and a generally interior cylindrical wall having communication with said hollow boss for the passage of steam therealong,
a nozzle extending along said support and having an interior wall portion forming a fluid flow conduit,
an exterior wall portion in communication with the steam inlet and spaced inwardly of the interior wall of said support and with the interior wall of said support forming an annular steam flow passageway,
the exterior wall of said nozzle diverging adjacent the discharge end thereof and terminating into a cylindrical end wall portion parallel with and cooperating with the interior cylindrical wall of said support to form a thin annular orifice,
a hollow nut threaded in the opposite end of said support from said orifice and retaining said nozzle in said support,
said nut being spaced from the end of said nozzle to accommodate limited freedom of movement of said nozzle,
to reduce the transmission of vibrations between said nozzle and said heater body,
spacer means determining the spacing between the cylindrical end wall portion of said nozzle and the interior cylindrical wall portion of said support,
and vibration damping means damping vibration of said nozzle and thereby deadening the sound caused by vibration of said nozzle, comprising an O-ring interposed between said nut and the upstream end of said nozzle.

4. In a direct contact fluid heater,
a heater body having a generally cylindrical interior wall portion,
a fluid inlet at one end of said body and a fluid outlet at the opposite end of said body, a hollow boss extending into said body through the wall thereof and having an interior cylindrical support portion extending in upstream and downstream directions from said boss in axial alignment with the center of said body and spaced inwardly of the cylindrical wall of said body,
a nozzle extending along the interior of said support and supported thereby and having an intermediate exterior wall portion spaced inwardly of the interior support portion of said support and with said support portion forming an annular steam passageway extending along said support,
said nozzle also having a hollow interior portion for the passage of water therethrough and exterior cylindrical end wall portions at opposite ends thereof, spaced outwardly of said intermediate wall portion and inwardly of the cylindrical interior wall of said support,
and spacer lugs at opposite ends of said nozzle spacing said exterior end cylindrical wall portions of said nozzle in predetermined radial spaced relation with respect to the cylindrical interior wall of said support and forming annular orifices directing thin annular streams of steam into the fluid flowing through said body contra to and in the direction of flow of the fluid therethrough.

5. A direct contact fluid heater comprising,
a heater body,
a fluid inlet leading into said body through one end thereof,
an axially aligned fluid outlet leading from the opposite end of said body,
said body having an interior wall portion between said

inlet and said outlet forming a conduit for the flow of fluid from said inlet through said outlet,

a support spaced inwardly of the wall of said conduit and having a hollow interior portion in communication with said fluid inlet,

a nozzle mounted in and extending along said support and having an interior wall portion for the flow of fluid therethrough and an exterior wall portion spaced a substantial distance from the hollow interior of said support for the flow of steam therealong and having upstream and downstream exterior wall portions conforming generally to the interior portion of said support and with said interior portion of said support forming thin nozzles directing thin ribbons of steam into the fluid flowing through said body contra to and in the direction of flow of fluid through said body inwardly of the interior wall of said body.

6. In a direct contact fluid heater,

a heater body,

a fluid inlet into said body through one end thereof,

a fluid outlet from said body through the opposite end thereof,

said body having a generally cylindrical wall between said inlet and said outlet,

a hollow boss extending into said body through the wall thereof and forming a steam inlet,

a hollow cylindrical support on the inner end of said boss and having an exterior wall spaced radially inwardly of the cylindrical wall of said body and a generally interior cylindrical wall having communication with said hollow boss for the passage of steam therealong,

a nozzle extending along said support and having an interior wall portion forming a fluid flow conduit,

an exterior wall portion in communication with the steam inlet and spaced inwardly of the interior wall of said support and with the interior wall of said support forming an annular steam flow passageway,

the exterior cylindrical wall of said nozzle diverging at opposite ends thereof and terminating into upstream and downstream end cylindrical wall portions,



spacer lugs at opposite ends of said nozzle spacing said end cylindrical wall portions of said nozzle from the interior cylindrical wall portion of said support,

a downstream end cylindrical exterior wall portion of said nozzle cooperating with one end of the interior wall of said support to form an annular steam orifice,

a nut threaded in the opposite end of said support and retaining said nozzle to said support, said nut having an interior cylindrical wall portion cooperating with the upstream end cylindrical wall portion of said nozzle and with said end cylindrical wall portion forming an annular orifice discharging steam into said body in a direction upstream of the direction of flow of water through said body,

and said other end exterior cylindrical wall portion of said nozzle cooperating with the interior cylindrical wall portion of said support and forming a thin annular orifice directing an annular ribbon of steam in the water flowing through said body in the direction of the flow of water through said body.

7. A direct contact fluid heater in accordance with claim 6 wherein said nut is spaced axially of said nozzle and accommodates limited freedom of movement of said nozzle to reduce the transmission of vibrations from said nozzle to said heater body.


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