United States Patent

[11] 3,584,194

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[21] Appl. No. **827,228**
[22] Filed **May 23, 1969**
[45] Patented **June 8, 1971**

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[54] **FLUID HEATING TECHNIQUES**
6 Claims, 8 Drawing Figs.

[52] **U.S. Cl.** **219/305,** 165/156, 210/234, 219/302, 219/308, 219/328, 239/135

[51] **Int. Cl.** **F24h 1/10,** H05b 1/02

[50] **Field of Search** 219/296, 299, 302, 303, 304, 305, 306, 308, 328; 165/156; 210/234; 239/134, 135, 139

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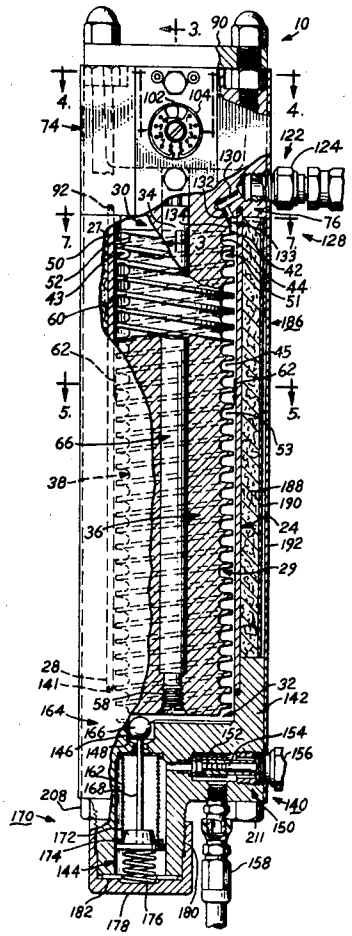
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ABSTRACT: Apparatus and method for heating fluid under pressure. The apparatus aspect of the disclosure includes a member that defines a chamber in which a source of heat and a radiator are located. The outer surface of the radiator defines pathways through which the fluid flows in the apparatus in order to be heated. A gap is provided between the radiator and the member so that fluid disposed in the gap partially insulates the fluid flowing in the pathways. Insulation is provided around the member and a thermostat is mounted in a cavity defined by a housing attached to the radiator so that the fluid is uniformly heated to a constant, predetermined temperature. A filter is held in an outlet assembly that automatically retains fluid in the chamber when the filter is removed for cleaning.



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SHEET 1 OF 2

Fig. 1

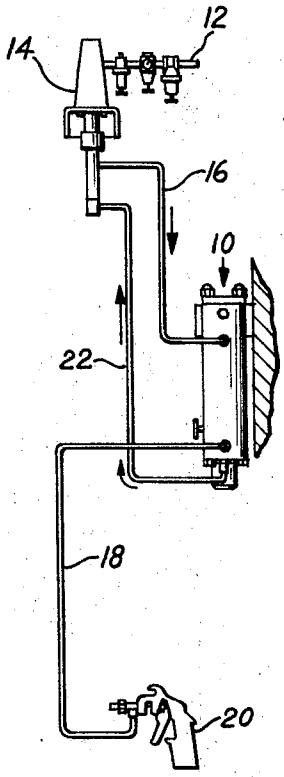


Fig. 2

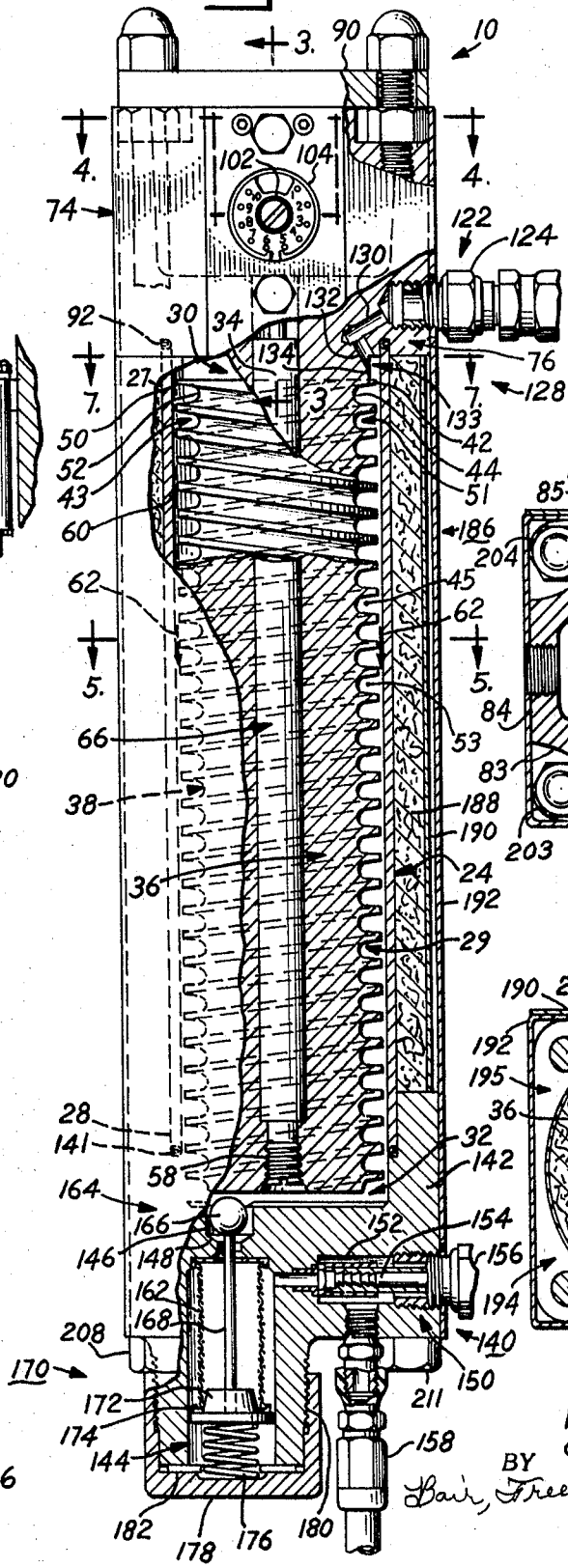


Fig. 3

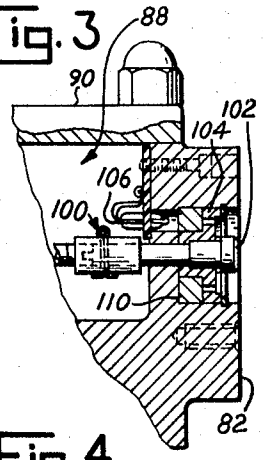


Fig. 4

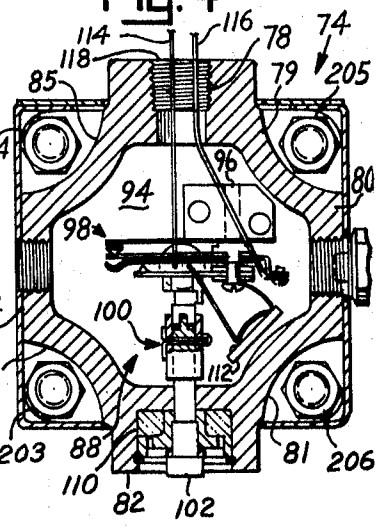


Fig. 5

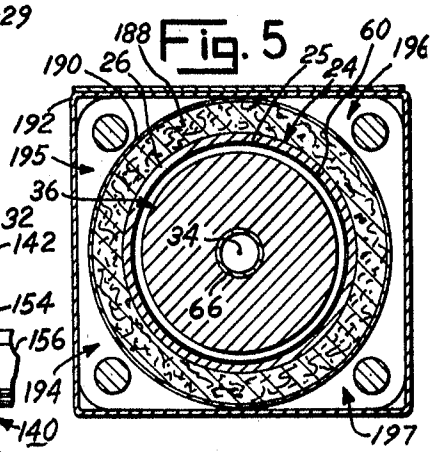
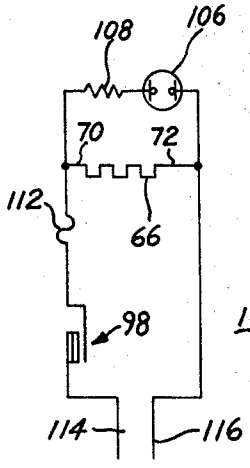


Fig. 6



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Fig. 7

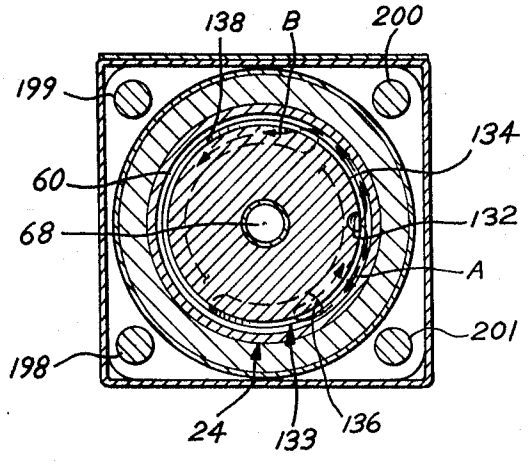
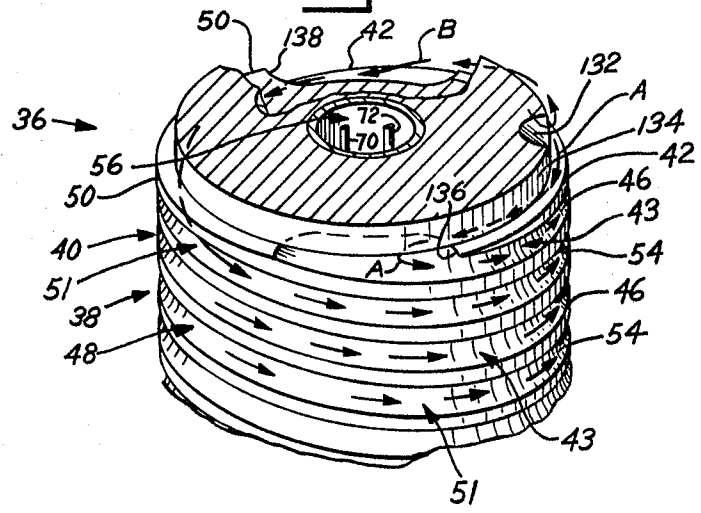


Fig. 8



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FLUID HEATING TECHNIQUES

BACKGROUND OF THE INVENTION

This invention primarily relates to techniques for heating fluid, and is more specifically directed to techniques for heating varnish, lacquers, enamels, and the like for use in hot spraying systems.

As a final step in most manufacturing processes, protective and decorative fluids such as paints, varnishes, lacquers, enamels, and the like are frequently applied to articles. The paint industry has long recognized that heating such fluids offers the advantages of reduced viscosity, reduced thinner requirements, and shorter application and drying times. In addition, heating the fluids improves coverage and the overall appearance of the finished article.

In light of these considerations, prior art systems adapted to apply protective and decorative fluids by spraying have typically included a fluid heater. However, each of the prior art fluid heaters has exhibited certain deficiencies that have limited its usefulness.

One of the deficiencies exhibited by prior art fluid heaters relates to their ability to heat fluid uniformly without "hot" spots. Prior art heaters generally have a relatively small heater area facing the fluid so that there is considerable danger of scorching the fluid if the heat flux-density is more than about 7 watts per square inch. Another problem exhibited by prior art heaters is their inability to control the maximum temperature to which the fluid is heated as the heater is turned on. In addition, certain prior art heaters have exhibited a considerable temperature gradient across the pathways taken by the fluid through the heater, so that some portions of the fluid are excessively heated, while other portions do not receive sufficient heat.

Prior art heaters are also deficient in their ability to control the temperature "bandwidth" of the fluid, that is, the temperature range between the highest and lowest temperatures to which the fluid is heated. More specifically, prior art fluid heaters are basically incapable of consistently heating fluid to a uniform, predetermined temperature over a sustained period of time. The inability of prior art fluid heaters to control the temperature bandwidth of the fluid is a serious problem since many new lacquers may be adversely affected unless the temperature to which they are heated is limited within a narrow range.

Another disadvantage of prior art fluid heaters is that they generally comprise drilled or cast-in holes through which the fluid travels as it is being heated. The nature of the holes is such that they are difficult, if not impossible, to clean when the heater receives periodic service. The servicing of prior art fluid heaters is also complicated by the filter arrangements used therein.

Accordingly, it is an object of the present invention to provide a fluid heater that heats fluid uniformly without creating "hot" spots and without scorching the fluid.

It is another object of the present invention to provide a fluid heater that can control the maximum temperature to which the fluid is heated as the fluid heater is turned on.

Another specific object of the present invention is to control the temperature gradient across the fluid as it is being heated.

Yet another object of the present invention is to enable fluid to be heated within a narrow range of temperatures over a sustained period of time, that is, to reduce the temperature bandwidth of a fluid heating system.

Still another object of the present invention is to provide improved means for servicing and cleaning a fluid heating system.

SUMMARY OF THE INVENTION

In order to overcome the deficiencies of prior art fluid heaters, the present invention, in its principal apparatus aspect, comprises a member that defines a chamber. The chamber contains a source of heat and a radiator means having an outer surface that defines pathways through which fluid flows as it is being heated. By properly arranging the pathways and distributing fluid therein, the fluid is heated to the desired temperature by applying a minimum heat flux-density so that the possibility of scorching is virtually eliminated.

In order to control the temperature gradient and the temperature range in which the fluid is heated (i.e., the temperature bandwidth), the present invention also provides a temperature-sensitive control means that controls the operation of the source of heat and insulation that surrounds the member. According to one embodiment of the invention, the control means is mounted in a cavity defined by a housing that is connected to the radiator means so that it can accurately determine the temperature to which the fluid is being heated. By employing the foregoing techniques, the temperature bandwidth and gradient of the system may be reduced to values unattainable by prior art methods and apparatus. As previously mentioned, this feature is vital for the proper heating and application of many fluids, such as lacquers, that may deteriorate unless the temperature to which they are heated is held within close tolerances.

Another aspect of the present invention that significantly increases the ability of the system to control its temperature gradient and bandwidth relates to the displacement of the radiator means from the member in order to form a gap. According to this feature, fluid flowing in the gap partially insulates the fluid flowing in the pathways from the member. As a result, the fluid flowing in the pathways is heated uniformly throughout, and the temperature gradient and bandwidth of the system may be precisely controlled.

In addition to the foregoing advantages and features, the radiator means is preferably supported at only one end portion of the chamber so that the radiator means may be easily removed from the chamber for cleaning purposes. Moreover, since the pathways defined by the radiator means are located to the exterior thereof, the entire radiator means may be easily cleaned and serviced.

Another aspect of the present invention relates to apparatus for conveniently mounting a fluid filter in connection with the fluid heater assembly. The apparatus includes a unique means for closing the chamber so that fluid is retained therein when the filter is removed for cleaning. When the filter is replaced, the means are automatically reset so that fluid is again allowed to flow freely through the chamber.

The use of the apparatus and method aspects of the present invention results in techniques by which fluid may be heated with a degree of control and accuracy unattainable by prior art apparatus. In addition, the present invention results in a system that is easy to assemble, service, and clean so that the overall cost of employing the techniques is significantly reduced.

DESCRIPTION OF THE DRAWINGS

These and other objects, advantages, and features of the present invention will hereinafter appear for purposes of illustration, but not of limitation, in connection with the accompanying drawings in which like numbers refer to like parts throughout, and in which:

FIG. 1 is a side elevational view of the exterior of a preferred form of fluid heater assembly made in accordance with the present invention, together with fragmentary, schematic illustrations of additional components with which the fluid heater assembly may be used in a fluid spraying system;

FIG. 2 is a partially fragmentary, cross-sectional front elevational view of the fluid heater assembly shown in FIG. 1;

FIG. 3 is a fragmentary, cross-sectional view taken along line 3–3 of FIG. 2;

FIG. 4 is a cross-sectional view taken along line 4–4 of FIG. 2;

FIG. 5 is a cross-sectional view taken along line 5–5 of FIG. 2;

FIG. 6 is a schematic electrical diagram illustrating the manner in which certain of the parts shown in FIGS. 3 and 4 are interconnected;

FIG. 7 is a cross-sectional view taken along line 7–7 of FIG. 2; and

FIG. 8 is a perspective, fragmentary view of a portion of the radiator means shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. 1, a preferred form of a fluid heater assembly **10** made in accordance with the present invention is shown in connection with a system that sprays protective and decorative fluid, such as paint. The system includes a main line **12** that supplied fluid to a pump **14**. The pump applies pressure to the fluid in a well-known manner so that fluid is forced through a supply line **16** to heater assembly **10**. After the fluid is heated, it flows through one portion of a coaxial line **18** to a spray gun **20**. The spray gun operates in a well-known manner to apply fluid to any article requiring decoration or protection. Unused fluid is continually returned to the heater assembly through another portion of coaxial line **18**. The unused fluid is then returned through a regulator line **22** to another portion of pump **14**. The entire system is controlled by regulators (not shown). The regulators automatically adjust the pressure in the coaxial and regulator lines so that an even flow of fluid is continually provided to the spray gun.

Referring to FIGS. 2—8, a preferred form of fluid heater assembly **10** made in accordance with the present invention comprises a cylindrical member **24**, a radiator assembly **36**, a heat source **66**, a housing assembly **74**, a control assembly **94**, an inlet assembly **122**, a distributing assembly **128**, an outlet assembly **104**, and an insulating assembly **186**.

As best shown in FIGS. **2**, **5**, and **7**, member **24** preferably comprises a stainless steel tube having an inner wall **25**, an outer wall **26**, a top end **27** and a bottom end **28**. The tube has an outside diameter of 3¼ inches and an inside diameter of 2 **63/64** inches. The inner wall of the member generally defines a chamber **29** having a first end portion **30**, a second end portion **32**, and a longitudinal axis **34**.

Radiator assembly **36** is generally held within chamber **29** and comprises an outer surface **38** that includes a threadset **40**. The threads of set **40** include crests such as crest **42** and a groove **43** having a base **44**. Threadset **40** defines a pathway **46** that has a midline arranged midway between the crests and groove base of the set. One point of the midline is identified by the number **45** (FIG. 2). Radiator assembly **36** also includes another threadset **48** that includes crests such as crest **50** and a groove **51** having a base **52**. Threadset **48** defines another pathway **54** that has a midline approximately midway between the crests and groove base of the set. One point of the midline is identified by the number **53** (FIG. 2). Threadsets **40** and **48** are identical in size and shape and are cast from aluminum with about 1½threads per inch. The radiator assembly **36** has a hollow center **56** that is sealed at the lower end thereof by a plug seal **58**. The crests of threadsets **40** and **48** are each displaced from the inner wall of member **24** by a gap **60** of about 0.014 inches. Gap **60** defines a cylindrical pathway **62** through which fluid may flow adjacent inner wall **25** from the first to the second end portion of chamber **29**. As previously mentioned, the fluid disposed in gap **60** provides a curtain or barrier that partially insulates the fluid flowing in pathways **46** and **54** from the member (the inner wall of which is somewhat cooler than outer surface **38**).

Heat source **66** comprises a 2,000 watt, 230 volt electrical element having a centerline **68** that is coincident with longitudinal axis **34**. Power is supplied to heat source **66** through conductors **70** and **72**. As best seen in FIG. **2**, the heat source extends substantially along the entire length of the radiator assembly, and, likewise, the radiator assembly extends substantially along the entire length of chamber **29**. As a result, a relatively large, evenly heated surface area is available in order to heat fluid flowing through the assembly so that hot spots and nonuniform heating is avoided.

Housing assembly **74** comprises a lower portion **76** that is preferably integrally formed with radiator assembly **36**. Housing assembly **74** also includes sidewalls **78—85** that form an explosion-proof cavity **88**. The cavity is enclosed by a cover **90**. Member **24** is securely aligned to lower portion **76** by a gasket **92** so that the first end portion of the chamber is effectively sealed.

Control assembly **94** is held within cavity **88** and basically includes a temperature-sensitive control device comprising a thermostat **98** that is mounted on a bracket **96**. Thermostat **98** controls the operation of heat source **66** in a well-known manner based on the temperature in cavity **88**. The thermostat is connected through a sleeve **100** to a knob **102** by which the setting of the thermostat may be manually regulated. When the apparatus is operating properly, light from a neon lamp **106** is diffused by a lens **110** and is projected onto a perforated dial **104**. Lamp **106** is connected in series with a resistor **108** that increases its effective life. The thermostat is also connected in series with a fusible heat limiter **112** that automatically disconnects heat source **66** when the temperature in cavity **88** exceeds a predetermined limit. Power is supplied to the control assembly from a 230 volt source through conductors **114** and **116** that extend through a threaded conduit hole **118**.

Inlet assembly **122** comprises a fitting **124** that is adapted to be connected to supply line **16** (FIG. 1).

Distributing assembly **128** comprises drilled channels **130** and **132** that are interconnected with fitting **124**, and a ring channel **133** that includes a wall **134**. As best shown in FIGS. **2**, **7** and **8**, the threadsets are arranged so that a first volume of fluid flowing in ring channel **133** follows the path marked by the set of arrows identified by the letter A and then proceeds along pathway **46**. More specifically, the first volume flows on top of crest **42** and adjacent wall **134** until it flows over a lip **136** into pathway **46**. A second volume of fluid flowing in ring channel **133** follows the path marked by the arrows identified by the letter B and then proceeds along pathway **54**. More specifically, the second volume flows on top of crest **42** and under a lip **138** until it enters pathway **54**. As a result of the unique structure of the distributing and radiator assemblies, the volumes of fluid flowing in pathways **46** and **54** are always equal. Moreover, since threadsets **40** and **48** are shaped and spaced in an identical manner, the fluid in each pathway is heated to exactly the same extent so that " hot" spots and uneven heating are completely avoided. A quantity of the fluid flowing in ring channel **133** also follows pathway **62** defined by gap **60** so that the fluid in pathways **46** and **54** is partially insulated from inner wall **25**. However, pathways **46** and **54** are considerably larger than pathway **62** so that only a relatively small percentage of the fluid flowing in ring channel **133** proceeds along the gap. As a result, most of the fluid flows along threadsets **40** and **48** where it is heated uniformly to a predetermined temperature.

Outlet assembly **140** includes a gasket **141** that seals bottom end **28** of member **24**. The outlet assembly also comprises a casting body **142** that defines a cavity **144**. The cavity communicates with chamber **29** through a passageway **146**. Passageway **146** includes a valve seat **148**. Outlet assembly **140** also includes a passageway **150** that comprises a tube **152**, a barb **154**, a fitting **156** that is connected to coaxial line **18**, and a fitting **158** that is connected to regulator line **22**. A filter **162** is adapted to fit inside cavity **144**. The passage of fluid through passageway **146** is controlled by a valve **164** comprising a biasing ball **166** that fits in valve seat **148**. The biasing ball has sufficient mass so that it is moved onto the valve seat by gravity when the filter is removed for cleaning and servicing. Valve **164** also comprises a stem **168** that is attached to ball **166** and passes through the center of filter **162**.

The operation of valve **164** is controlled by an operating assembly **170**. The operating assembly includes a rider **172** that is releasably attached to stem **168**, and a gasket **174** that fits on the rider and engages the lower end of filter **162**. The operating assembly also includes a spring **176** and a threaded cap **178** that can be screwed onto threads **180** of the outlet as-

sembly. The operating assembly is sealed by a gasket **182** so that all of the fluid flowing through passageway **146** passes through the filter before it is expelled through passageway **150**.

Insulating assembly **186** comprises a 1-inch thick, cylindrical insulating tube **188** that is fabricated from glass fiber. As best shown in FIG. **2**, the insulating tube extends from the lower portion **76** of housing assembly **74** to the upper portion of casting body **142**. The insulating tube is surrounded by a cylindrical metal member **190** that is fabricated from aluminum. The outer portion of the insulating assembly is formed by a 0.032-inch thick steel jacket **192** that is arranged to define closed air spaces **194—197**.

The entire heater assembly is held together by bolts **198—201**. The bolts are held in position at the top end of the heater assembly by hex nuts **203—206**, respectively, and at the lower end of the assembly by hex nuts **208**, **211**, and two additional hex nuts not shown. Four acorn nuts positioned above hex nuts **203—206** hold cover **90** in place. The entire assembly has an overall length of about 21 inches.

The operation and method aspect of the preferred embodiment will now be described. The fittings of the heater assembly are connected to appropriate lines of the apparatus shown in FIG. **1** in the manner previously described. In addition, conductors **114** and **116** are connected to a source of 230 volt electrical power (110 volt power may also be used if the values of the components in the control assembly are appropriately chosen). When the heater assembly is connected in the manner described, fluid under pressure flows through fitting **124** and channels **130**, **132**, into ring channel **133**, and the upper portion of the radiator assembly basically divides the fluid into two quantities. A first quantity of the fluid is propelled in a space adjacent the radiator assembly (i.e., along pathways **46** and **54**). Of course, in the preferred embodiment, the first quantity is divided into equal volumes of fluid that are propelled along pathways **46** and **54**, respectively. The first quantity of the fluid is substantially surrounded by a second quantity of the fluid that is confined in a cylindrical space along inner wall **25** in gap **60**. The space extends from the first to the second end portion of chamber **29**. The first quantity of the fluid is substantially greater than the second quantity of the fluid. As a result of this method of operation, the temperature gradient across pathways **46** and **54** is substantially reduced, and the fluid is uniformly heated to the same temperature with a degree of precision unattainable by the use of prior art methods.

After fluid is heated in the manner described, it is expelled through the outlet assembly and filter **162** in an obvious manner.

The temperature to which the fluid is heated may be regulated by operating knob **102** of control assembly **94**. As previously mentioned, many lacquers require heating to a predetermined temperature that is maintained constant within very close tolerances. Applicants have found that use of the techniques described herein enable control assembly **94** and heat source **66** to consistently heat a fluid to a predetermined temperature with a degree of accuracy heretofore unattainable. Applicants have found that the arrangement of parts shown herein not only reduces the temperature gradient across pathways **46** and **54**, but also reduces the system bandwidth.

Radiator assembly **36** may be easily cleaned by removing hex nuts **203—206** and the corresponding acorn nuts. The radiator assembly may then be lifted out of chamber **29**. Since the radiator assembly is secured only at the first end portion of the chamber, it may be removed easily and conveniently. Once the radiator assembly is removed, the threadsets are exposed to the operator and may be easily cleaned.

Filter **162** may be conveniently cleaned by removing cap **178**, spring **176**, and rider **172**. As the filter is removed from cavity **144**, biasing ball **166** is lowered by gravity into contact with valve seat **148**, thereby effectively preventing fluid in chamber **29** from flowing through the outlet assembly. When the filter is replaced and the rider, spring and threaded cap are repositioned as shown in FIG. **2**, the biasing ball is moved above the valve seat so that fluid may flow throughout the outlet assembly in the manner previously described.

A thermometer may be inserted in a hole in casting body **142** in order to continuously monitor the temperature at which the fluid is being heated.

Those skilled in the art will appreciate that the present invention has been described in connection with a particular embodiment thereof, and that various structural changes and modifications of the mode of operation may be affected without departing from the spirit and scope thereof.

What We claim is:

1. In a system designed to heat fluid under pressure, apparatus comprising:

a member that defines a chamber having a first end portion and a second end portion;

a source of heat;

radiator means coupled to said source of heat and located in the chamber for defining a first spiral pathway by which fluid flows along the exterior of the radiator means from the first end portion toward the second end portion of the chamber, said radiator means being displaced from said member by a predetermined gap that forms a second cylindrical pathway in which fluid flows, whereby the fluid flowing in the first spiral pathway is partially insulated;

inlet means for receiving fluid under pressure and for conducting said fluid to said first and second pathways;

outlet means for expelling heated fluid from said chamber;

a housing connected to the radiator means, said housing defining a cavity;

a temperature-sensitive control means mounted in said cavity for controlling the energization of the source of heat; and

insulating means for insulating the member so that the temperature gradient across the first pathway is minimized and so that the temperature to which the fluid in the first pathway is heated remains substantially constant.

2. Apparatus, as claimed in claim **1**, wherein the insulating means comprises:

a fibrous layer of material that substantially surrounds the member;

a metal member that substantially surrounds the fibrous layer; and

a jacket that substantially surrounds the metal member for creating closed air spaces between the metal member and the jacket.

3. Apparatus, as claimed in claim **1**, wherein the gap is at least 0.010 inches wide.

4. Apparatus, as claimed in claim **1**, wherein the gap is about 0.014 inches wide.

5. Apparatus, as claimed in claim **1**, wherein said outlet means comprises:

a body underlying the chamber that defines a cavity;

a first passageway for connecting the cavity with the chamber;

a second passageway for connecting the cavity with the exterior of the outlet means;

a filter adapted to be inserted in the cavity;

a vertical stem mounted in said first passageway;

closure means attached to the top end of the vertical stem, said closure means having a first position in which the first passageway is closed and a second position in which the first passageway is open;

bias means for normally biasing the closure means in its first position so that fluid is held in the chamber if the filter is removed; and

operating means for moving the closure means to its second position if the filter is inserted in the cavity so that heated fluid flows from the chamber to the exterior of the outlet means through the filter.

6. Apparatus, as claimed in claim **5**, wherein the operating means comprises a spring and a gasket that hold the closure means in its second position and that simultaneously hold the filter in the cavity.