United States Patent

[11] 3,596,639

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[45] Patented **Aug. 3, 1971**
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[54] **TELESCOPING SLEEVE HEATER**
11 Claims, 14 Drawing Figs.

[52] **U.S. Cl.** **122/149**
[51] **Int. Cl.** **F22b 7/12**
[50] **Field of Search** 122/136, 149, 37

[56] **References Cited**

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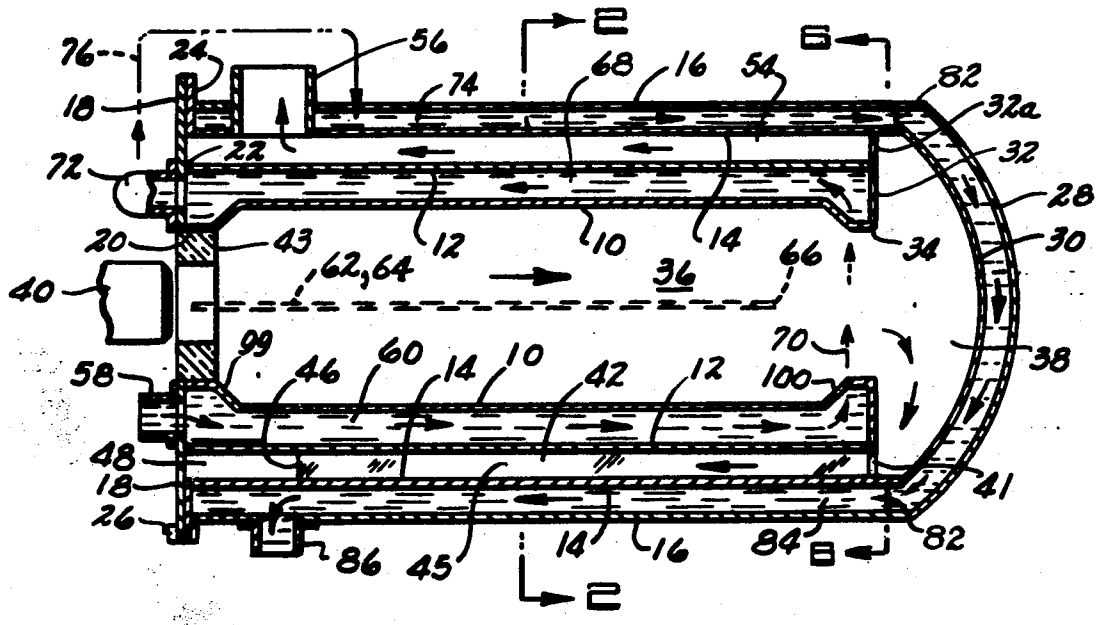
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Primary Examiner—Kenneth W. Sprague
Attorneys—John E. McRae, Tennes I. Erstad and Robert G. Crooks

ABSTRACT: A fluid heater, primarily for water, wherein the hot combustion gases and heat-absorbing fluid flow through separate sinuous passage systems formed by four telescoping sleeves and radially spaced partitions in the annular spaces between adjacent sleeves.



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SHEET 1 OF 3

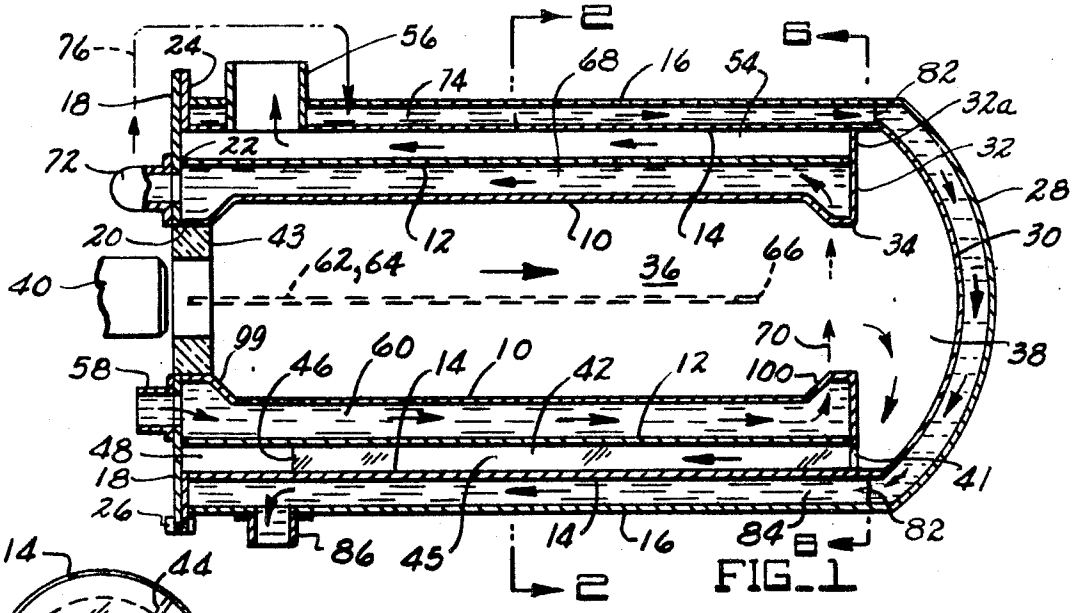


FIG_1

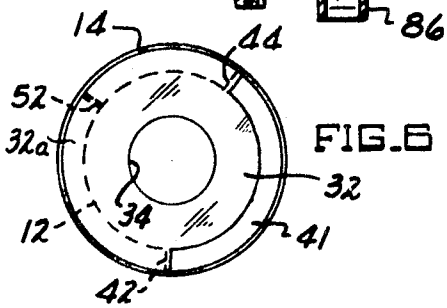


FIG_6

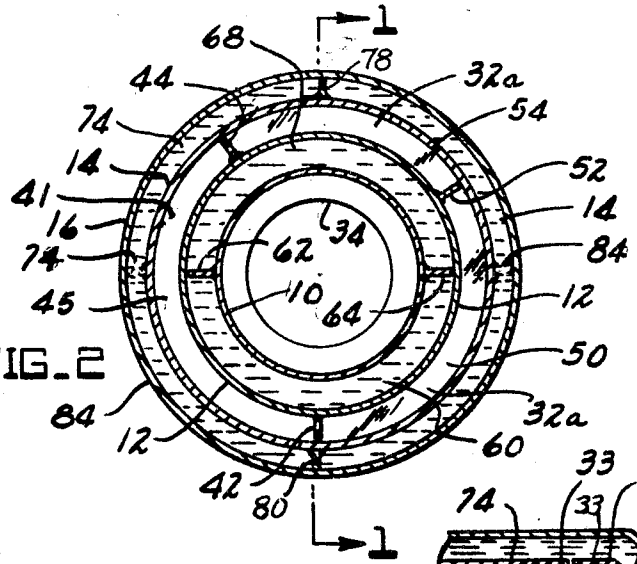


FIG_2

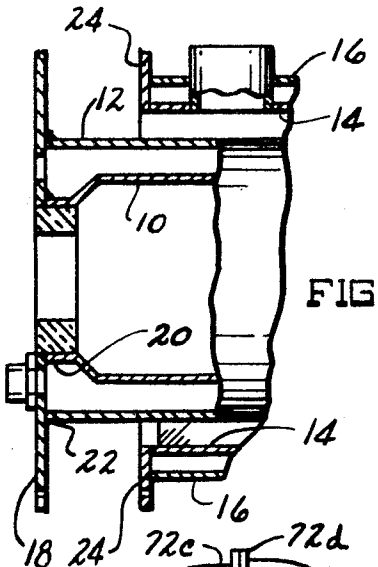


FIG_5

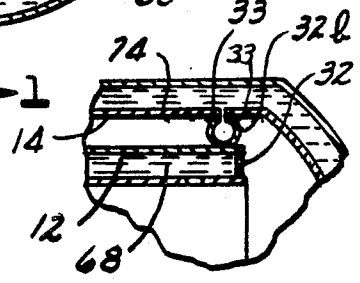


FIG_4

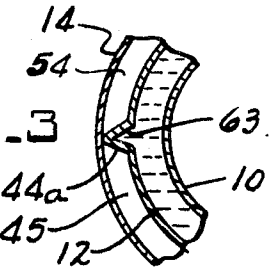


FIG_3

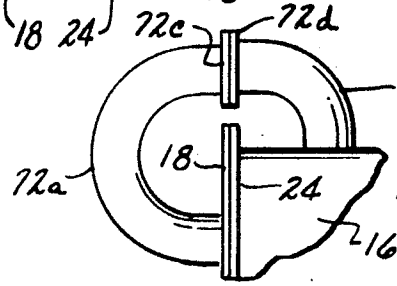


FIG_7

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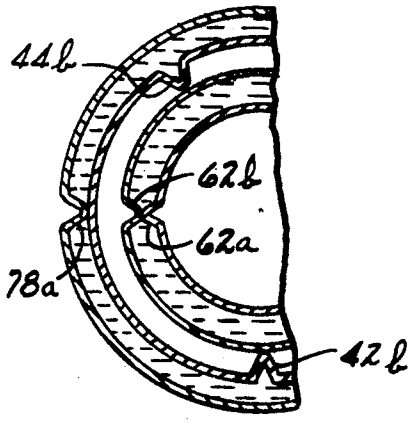


FIG_9

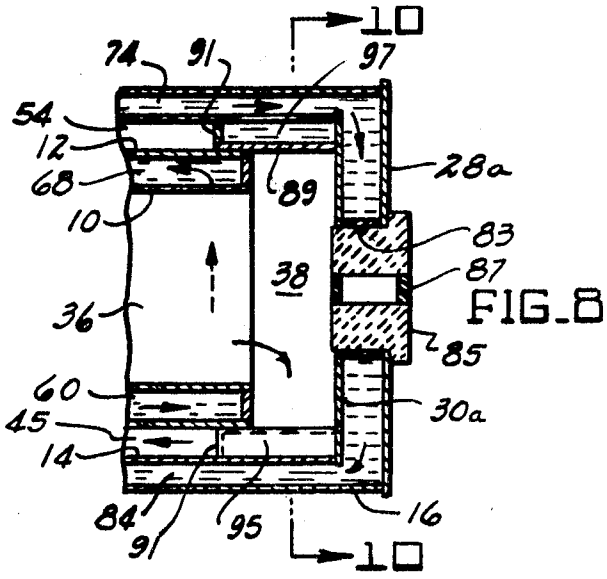


FIG_8

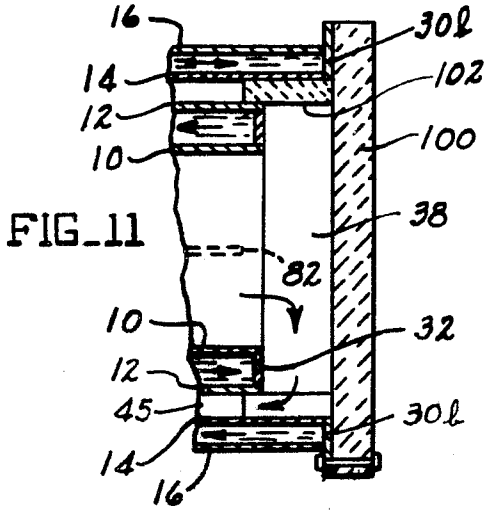


FIG_11

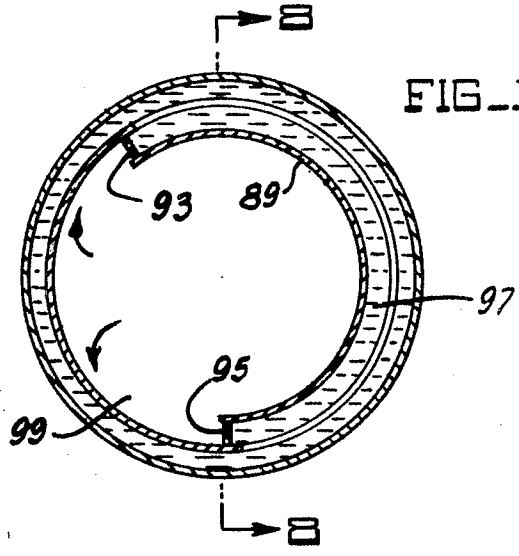


FIG_10

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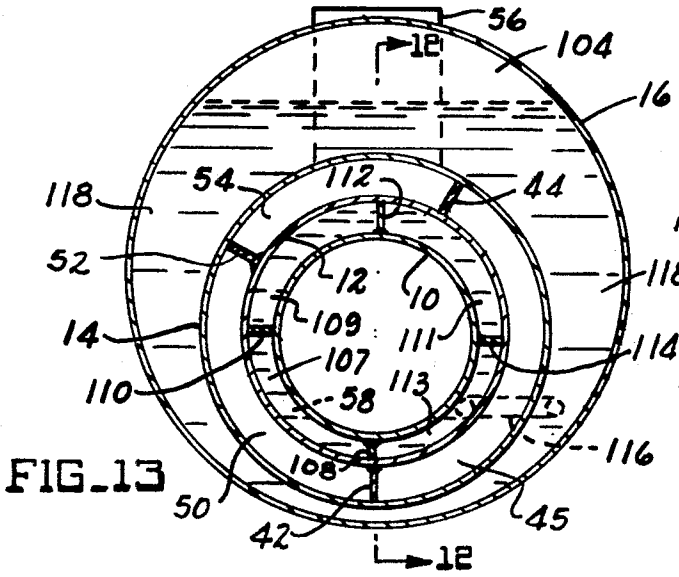


FIG_13

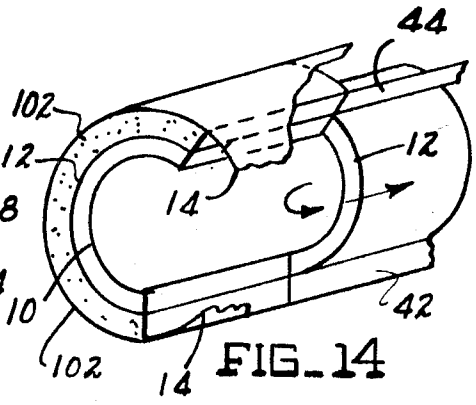


FIG_14

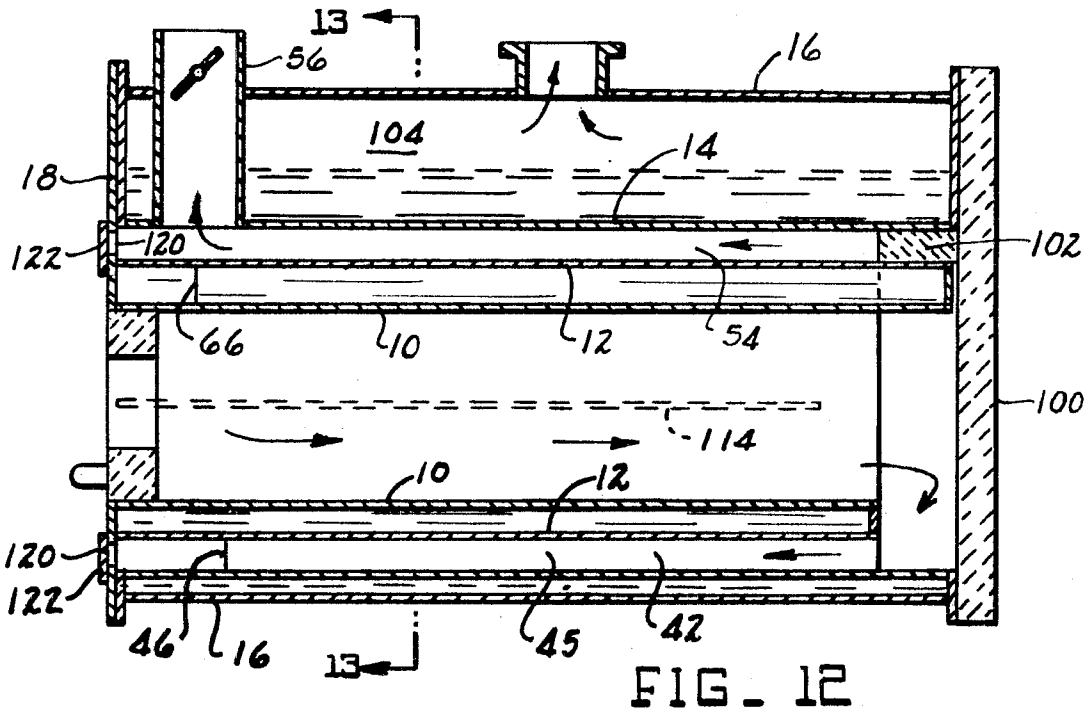


FIG_12

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TELESCOPING SLEEVE HEATER

THE DRAWINGS

FIGS. 1 and 5 are sectional views of a heater built under the invention; the FIGS. are taken on line 1–1 in FIGS. 2.

FIG. 2 is a sectional view taken on line 2–2 in FIG. 1.

FIGS. 3, 4, 8, 9, 10 and 11 are fragmentary sectional views showing details of construction that may be used in lieu of certain details shown in FIG. 1.

FIG. 6 is a fragmentary sectional view on a reduced scale, taken on line 6–6 in FIG. 1.

FIG. 7 is a fragmentary plan view looking down on the heater of FIG. 1.

FIG. 12 is a sectional view of another embodiment of the invention taken on line 12–12 in FIG. 13.

FIG. 13 is a sectional view on line 13–13 in FIG. 12.

FIG. 14 is a perspective view schematically illustrating a feature of construction used in the FIG. 12 embodiment.

FIG. 1

The heater of FIG. 1 comprises four concentric sleeves **10**, **12**, **14** and **16** suitably connected to a front closure plate **18**. Sleeves **10** and **12** have their front end edges seam welded to plate **18**, as at **20** and **22**. Sleeves **14** and **16** have their front edges seam welded to an annular seal plate **24**. Bolts **26** may run through holes in the peripheral face areas of the two plates **18** and **24**, to removably connect said plates together. FIG. **5** shows the inner assembly (members **10**, **12** and **18**) partially removed from the outer assembly (members **14**, **16** and **24**), as during the process of fabrication or during maintenance periods.

The rear end edge of sleeve **16** is seam welded to an elliptically contoured rear closure plate **28**, and the rear end edge of sleeve **14** is welded to an elliptically contoured rear closure plate **30**. Plates **28** and **30** can be flat; however the assembly is stronger when the plates are elliptical. The rear end edges of sleeves **10** and **12** are welded to a flat rear closure plate **32**, said plate having a circular opening **34** therethrough for communicating the central sleeve space **36** with the gas reversal zone **38** located forwardly of plate **30**.

The annular space between sleeves **10** and **12** forms a primary heat-absorbing fluid chamber; it is subdivided into two longitudinal passages by two radial partitions **62** and **64**. The annular space between sleeves **12** and **14** forms a secondary hot gas chamber; it is subdivided into three passages by three radial partitions **72**, **44** and **52**. The annular space between sleeves **14** and **16** forms a secondary heat-absorbing fluid chamber; it is subdivided into longitudinal passages by two radial partitions **78** and **80**.

HOT GAS PASSAGE SYSTEM

Heat may be supplied to the heater by means of a conventional gas or oil burner **40** arranged to discharge the fuel-gas into sleeve **10**. Sleeve **10** constitutes a combustion tube for reception of the burning gas flowing toward the opening **34**. As the hot gases impinge against wall **30** they are deflected or directed through a sectorlike opening **41** in plate **32**, and thence into a longitudinal passage **45** formed between sleeves **12** and **14**. As shown in FIG. **2**, passage **45** is further defined by two longitudinal radial partitions **42** and **44** spaced from one another by about 150 radial degrees. Opening **41** has the same shape and flow area as passage **45** so that one is the continuation of the other. The hot gases proceed forwardly through passage **45** until they reach the front edge **46** of partition **42**, whereupon they pass through the rectangular opening **48** formed between the partition edge **46** and the front closure plate **18**.

After passing through the opening **48** the gases are caused to move rearwardly in a second longitudinal passage **50** defined by the two cylinders **12** and **14**, and the two radial partitions **42** and **52**. Passage **52** is about 120 radial degrees as measured in FIG. **2**. The rearwardly flowing hot gases strike against the front face of a baffle **32***a* e formed as part plate **32**. As shown in FIG. **6**, baffle **32***a* extends about 210 radial degrees with respect to the tube axis so as to blank off the the arcuate space going from partition **42**, through **52** and to **44**. Baffle **32***a* is exposed to very hot gases on both its front surface and its back surface; it must therefore be formed of heat resistant material. Perhaps a better expedient is to form the baffle as a water-cooled baffle as a water-cooled baffle, as shown in FIG. **4**, to be described hereafter.

As the gas in passage **50** strikes the front face of baffle **32***a* it is deflected upwardly through an opening formed between the the rear edge of partition **52** and the baffle **32***a*. The described opening is similar in shape and size to the previously described opening **48**, but is located at the rear extremity of partition **52**. The gases move through this opening into a longitudinal passage **54** formed by the partitions **52** and **44**. As shown by the arrows in FIG. **1**, the hot gases flow forwardly and out through a stack **56** suitably welded to sleeve **14** and projecting through the sleeve **16** as a sealed connection.

It will be noted that segmental gas passage **45** covers 150 radial degrees, whereas gas passage **50** covers 120 radial degrees, and gas passage **54** covers only 90 radial degrees. Passage **45** thus has the greatest cross section, and passage **54** has the smallest. As the gas proceeds through the passage system it becomes cooler and its density decreases. By progressively reducing the passage cross section the linear gas velocity can be kept fairly constant throughout its travel through the heater, thereby achieving best scrubber action of all the heat transfer surface.

FLUID PASSAGE SYSTEM

The fluid to be heated may be water, oil or other liquid; alternately the fluid can be a gas such as air. The design of the heater makes it particularly useful in heating liquids which have greater heat-absorbing abilities then gases.

The fluid is introduced to the heater through a tubular fluid inlet **58** mounted on the front closure plate **18** in direct registry with a passage **60** formed by the sleeves **10** and **12**. As best shown in FIG. **2**, passage **60** is further defined by two radial partitions **62** and **64** suitably welded to sleeve **10**. Fluid flows through passage **60** in a rearward direction until it reaches the rear edges **66** of partitions **62** and **64**. The open space between the partition edges **66** and the closure plate **32** allows the fluid to flow upwardly into a second passage **68**, as denoted by arrows **70**.

Fluid flows forwardly in passage **68** and exits through a crossover pipe **72** which is mounted on the front closure plate **18**. Pipe **72** is directed laterally, rearwardly, and then back to sleeve **16** to conduct the fluid into the segmental passage **74** formed between the sleeves **14** and **16**. The full extent of pipe **72** is not visible in FIG. **1**, but its operational connection is denoted in FIG. **1** by the directional line **76**.

Preferably the crossover pipe **72** is mounted on the external surfaces of the heater so that the pipe can be disconnected or removed without disturbing the various concentric cylinders. By so locating the pipe the inner assembly (closure plate **18** and sleeves **10** and **12**) can be removed from the space circumscribed by sleeve **14** without interference from pipe **72**. FIG. **7** shows one method of disconnecting the pipe. As there shown, the pipe is made in two flanged sections **72***a* and **72***b*. By removing the bolts (not shown) from the mating flanges **72***c* and **72***d* it is possible to disconnect the pipe and permit ready disassembly of the inner and outer sleeve assemblies. Pipe section **72***a* remains connected to the inner sleeve assembly, while pipe section **72***b* remains attached to the outer sleeve assembly. Only one pipe joint needs to be disconnected.

Fluid passage **74** is defined by the two sleeves **14** and **16** and two radial partitions **78** and **80**; the passage thus occupies one-half of the sleeve circumference. Partitions **78** and **80** have their rear edges **82** apaced forwardly from the wet back section defined by closure plate **28** and **30**. Passage **74** fluid can

thus flow through the wet back section and into another longitudinal passage **84** which occupies the other one-half of the cylinder circumference, i.e. the segmental space to the right of partitions **78** and **80** in FIG. **2**. As shown in FIG. **1**, the fluid exits from the heater through a tubular outlet **86** located near the front of the heater. In actual practice outlet **86** would be offset to one side of partition **80**, hence not visible in FIG. **1**.

HEAT TRANSFER ACTION

It is believed that heat absorption by the fluid while in the heater is improved when the fluid is caused to have a significant and positive velocity across the heater surfaces. For this reason the water pump (not shown) is preferably operated whenever the burner is energized. If necessary the pump can be continuously energized or it can be programmed by the same thermostat or other control which cycles the burner.

The pump gives the water a positive velocity such that it is prevented from stagnating at any point in the heater. New fluid films continually replace the fluid at the liquid-metal interface, thus causing the metal surfaces on the water side to be relatively cool. For example, assuming a combustion gas temperature of 2,000° F., calculations indicate that by causing a forced circulation of the water through the heater it is possible to keep the metal temperatures at the liquid interface somewhere near 250° F., whereas the corresponding interface in a conventional tube-shell boiler would be somewhere near 370° F. The lower metal temperatures at the metal-liquid interface provide an increased temperature differential between the hot gases and the heat-absorbing fluids, thus providing a greater thermal driving force and higher heat release rate, due to a better heat drawout action.

The illustrated heater is somewhat similar to the hater shown in U.S. Pat. 2,040,959 issued to A. F. Schumann. However in the Schumann design the fluid passages defined by the concentric sleeves are not subdivided by means of longitudinal partitions. Therefore the fluid can flow circumferentially as well as longitudinally; it does not have a directional characteristic that is as pronounced or definite as in the present design. The present use of longitudinal partitions, coupled with positive circulation, is believed to produce a directional fluid flow with complete scavenging and scrubbing action at the liquid-metal interface.

In the illustrated device the various sleeves are preferably spaced fairly close together, as for example 1½ inches for the two small sleeves, and three-fourth inch for the two larger sleeves. The narrowness of the passages produces relatively high fluid velocities, thereby improving the heat transfer action. Further increase in fluid velocity can be achieved by increasing the number of radial partitions. For example, FIG. **2** shown two partitions **62** and **64** dividing the annular chamber between sleeves **10** and **12** into two longitudinal passages. By using four partitions in this annular space it is possible to double the number of passages and to double the linear velocity of the fluid (because the various passages are in series flow relation).

THERMAL STRESS

One major consideration in the design of a high heat release heater is the problem of thermal stress due to excessive heating of the metal surfaces. The illustrated design has a fairly low thermal stress characteristic because the fluid is caused to continuously wash the metal surfaces, as previously described. Additionally the thermal stress is minimized because the inner assembly, comprising plate **32** and inner sleeves **10** and **12**, is floatably disposed within the space circumscribed by sleeve **14**. Thus, axial expansion of the inner sleeve assembly can be relieved by slight movement of the plate **32** rightwardly.

Sleeve **10** will have a higher temperature than sleeve **12**, and sleeve **10** may undergo some thermal elongation relative to sleeve **12**. To alleviate any stress between sleeve **10**, plate **32** and sleeve **12**, the inner sleeve may be provided with inturned frustoconical sections **99** and **100** adjacent either or both of its ends, said frustoconical sections being capable of deflecting movement incident to thermal elongation of the inner sleeve, thereby relieving the thermal stress.

FLUID CONNECTIONS

Frustoconical section **99** serves as a splash deflector or fluid distributor since it is located in partial alignment with fluid inlet **58**. Thus, the incoming fluid is deflected by the conical surface at **99** to better fan out into passage **60**. The inlet **58** would in most cases have a diameter which is greater than the spacing between sleeves **10** and **12**. Therefore the inturned wall section **99** advantageously provides an enlarged space at the inlet end of passage **60**, thereby permitting a single adequately sized inlet **58** to be used for admitting all of the fluid to the heater. Similarly, all the fluid can be exhausted from passage **68** through a single adequately sized crossover pipe **72** because the enlarged fluid space provided by conical section **99** permits the pipe to be adequately sized.

INSPECTION AND MAINTENANCE

As previously noted, the inner sleeve assembly can be withdrawn from the space circumscribed by sleeve **14**. The purpose in such an operation is to permit inspection of the sleeve surfaces and cleaning of any surfaces having carbon incrustations thereon. It will be seen that when the two sections are thus separated all of the gas contact surfaces are exposed for easy cleanout. The surfaces presented to the heat-absorbing fluid are sealed. However cleanout of such surfaces can very often be accomplished by pumping a cleaner solution through the fluid passages. The series-flow relation of the passages enables the cleaning fluid to have a relatively high velocity and to thus have a thorough scrubbing action on the surfaces for removal of scale, calcium deposits, etc.

WET BACK OPERATION

It is believed that best operation, as regards heat release and thermal stress, is obtained when a major part of the gas-contacted surface is directly washed by the fluid being heated. With the present design the only inactive surfaces are baffle **32*a***, parts of front plate **18**, and the various radial partitions. Other than these inactive surfaces, all surfaces between the refractory **43** and stack **56** are active as heat transfer surfaces.

FIG. **3** illustrates a hollow partition structure which can be employed in lieu of that flat partition construction shown in FIG. **3**. Thus, as shown in FIG. **3** partition **44*a*** for sleeve **12** can be formed as a hollow protruding rib. The fluid in sleeve **12** can then fill the rib hollow spaces **63**, and the fluid in passages **45** and **54** can transfer heat directly through the rib **44*a*** surface. Such action cools the rib and tends to prolong its service life.

In a similar manner, the baffle **32*a*** may be more effectively cooled by making it in the form of a hollow fluid filled element **32*b*** as shown in FIG. **4**. In the FIG. **4** construction the baffle takes the form of a tube welded to sleeve **14** at **33** and having small holes at spaced points thereon opening to water passage **74**. These small holes permit automatic fill-up of the tube and venting of an excess vapor pressure. Tube **32*b*** extends around the circumference of cylinder **14** for about 210° i.e. the same distance as baffle **32*a***. The ends of the tube are of course plugged. In operation, the fluid in tube **3*b*** tends to absorb the heat of the hot gas as it impinges on the front and rear faces of the tube, thus tending to improve heat transfer and the service life of the baffle.

In the FIG. **4** design, maintenance operations include drawout of the inner sleeve assembly from the outer assembly, as with the design of FIG. **1**. However the tube-type baffle **32*b*** remains with outer sleeve assembly during such drawout operations; in the FIG. **1** design the baffle **32*a*** was attached to the inner sleeve assembly and moved with it during the drawout operation.

The drawings shown the heater with its axis arranged horizontally. However it will be appreciated that the heater

can be used in a vertically oriented position. Thus, the terms front, rear, back, etc. are used in a relative sense.

FIGS. 8 AND 10

FIG. 8 illustrates a variation of the invention wherein the rear end of the heater is closed by two flat cylindrical closure plates **28***a* and **30***a*, said plates defining a wetback section for conveying water or other fluid from passage **74** to passage **84**. A cylindrical sleeve **83** may be welded to plates **28***a* and **30***a* to form an access opening for personal entry into the combustion space. Refractory plug **85**, equipped with a Pyrex observation window **87**, is suitably mounted in sleeve **83** during normal operating periods.

The baffling of combustion gases into the various longitudinal passages may be accomplished by means of an arcuate plate **89**, a flat sector-shaped plate **91**, and two longitudinal partitions **93** and **95**. These plates form a water space **97** which extends approximately 210 radial degrees around the shell circumference; the remaining 150° forms a gas passage **99** for directing hot gases from gas reversal zone **38** into the longitudinal passage **45**. The arrangement functions in a similar fashion to the water-cooled baffle **32***b* shown in FIG. **4** or the noncooled baffle **32***a* shown in FIG. **1**.

FIG. 9

FIG. **9** illustrates various ways of forming the longitudinal partitions which separate the four concentric sleeves into longitudinal passages. Thus, the partitions can be formed as inwardly directly hollow ribs, as shown at **42***b*, **44***b*, and **78***a*. Alternately the ribs can be mating ribs projecting toward one another from adjacent sleeves, as shown at **62***a*, **62***b*. The aim in each case is to provide a water-cooled rib structure for more extensive heat transfer and prolonged service life.

FIG. 11

FIG. **11** is similar to FIG. **8** except that the rear closure is formed by a cast refractory disk **100**, and the gas-directing baffle is formed by a C-cross sectioned refractory baffle element **102**. The baffle is open for about 15° around the sleeve **12** circumference, thus providing a port for admitting the hot combustion gases to passage **45**. The gas and water flow paths are similar to the paths previously described.

In the FIG. **11** construction the two sleeves **14** and **16** are preferably sealed at their rear edges by an annular metal plate **30***b*. The refractory disk **100** may be removably clamped to plate **30***b* by various means such as C-clamps, through bolts, hinge-latch arrangements of one type or another, etc. The removability of the refractory permits easier replacement should the hot gases tend to erode through the refractory.

FIGS. 12 THROUGH 14

FIGS. **12** and **13** illustrate the invention as applied to a water heater adapted to produce steam. In this arrangement the outer tube **16** is eccentric with respect to sleeve **14** to define a steam collection space **104**. Hot gases are produced in tube **10**, as in the previous embodiments.

The hot gases produced in tube **10** impinge against cast refractory closure **100**, as in FIG. **11**. The gases are then directed into passage **45** via a C-cross sectioned refractory similar to refractory **102**. Inner sleeve assembly **10**, **12** differs slightly from that of FIG. **11** in that the two sleeves are cut away for about 150 radial degrees at their rear edges, as shown best in schematic FIG. **4**. The C-cross sectioned refractory **102** encircles the noncutaway areas of the tubes to thus form the port for admitting the hot gases to the passage **45**. Suitable plates, not numbered, are provided to seal the spaces formed by the cutouts in the sleeves **10** and **12**. General gas flow is similar to that previously described for FIG. **1**, etc.

Water flow is somewhat different in FIGS. **12** and **13** as compared to the previously described embodiments. As illustratively shown in FIG. **13**, the primary heat-absorbing chamber (sleeves **10** and **12**) may be subdivided into four longitudinal passages **107**, **109**, **111** and **113** by means of four partitions **108**, **110**, **112** and **114**. Water flows rearwardly in passage **107**, forwardly in passage **109**, rearwardly in passage **111**, and forwardly in passage **113**. The various partitions are staggered toward or away from the front closure plate **18** to provide the fluid connections from one passage to another. Water exits from passage **113** via crossover pipe **116** which may be formed in somewhat the same fashion as pipe **72** (FIGS. **1** and **7**). Pipe **116** directs the water into the outer chamber **118** formed between sleeves **14** and **16**.

The water in chamber **118** is heated by the hot gases flowing through passages **45**, **50** and **54**, and by the relatively hot water received from pipe **116**.

To facilitate clean out of the flue passages **45**, **50** and **54**, there may be formed through plate **18** a series of arcuate segmental openings or slots **120** closed by one or more removable access plates **122**. Conventional brushes may be run through these slots to dislodge soot without removing the inner sleeve assembly. Removal of the inner assembly would then only be necessary for inspection and/or repair. Similar slot-plate arrangements can of course be provided in the other forms of the invention.

I claim:

1. A fluid heater comprising four telescoping sleeves, including a first inner sleeve, a second intermediate sleeve larger in diameter than the first, a third intermediate sleeve larger in diameter than the second, and a fourth outer sleeve larger in diameter than the third; front closure means for the annular space between the inner and outer sleeves; rear closure means for the space circumscribed by the fourth sleeve; the inner sleeve constituting a combustion tube for reception of burning gases flowing from front-to-rear; the space immediately forward of the rear closure means constituting a hot gas reversal zone; the annular space between the first and second sleeves constituting a primary heat-absorbing chamber; the annular space between the second and third sleeves constituting a secondary hot gas chamber; the annular space between the third and fourth sleeves constituting a secondary heat-absorbing chamber; port means connecting the gas reversal zone with the secondary hot gas chamber; said primary heat-absorbing chamber and said secondary hot gas chamber having longitudinal partitions therein subdividing the respective chambers into longitudinal passages having segmental cross sections, successive ones of said passages in the respective chambers having fluid connections with one another at different ends of the heater whereby the hot gases and heated fluid are required to flow longitudinally back and forth in sinuous paths in order to traverse the heater.

2. The heater of claim **1** comprising a baffle going across the annular space between the second and third sleeves adjacent their rear ends; said baffle having an opening therethrough placing the hot gas reversal zone in fluid communication with one of the passages in the secondary hot gas chamber; said opening constituting the aforementioned port means said baffle comprising a hollow chamber having fluid communication with the space between the third and fourth sleeves, whereby the baffle is fluid-cooled.

3. The fluid heater of claim **1** wherein said port means if formed by a baffle which takes takes the form of a refractory wall partially encircling the second sleeve.

4. The heater of claim **1** wherein the front closure means comprises a first seal means for the annular space between the first and third sleeves, and a second seal means for the annular space between the third and fourth sleeves; the first and second sleeves cooperating with the first seal means to form an integral subassembly which can be drawn out of the space circumscribed by the third sleeve.

5. The heater of claim **4** and further comprising a fluid crossover pipe connecting one of the passages in the primary heat-absorbing chamber with one of the passages in the secondary heat-absorbing chamber; said pipe having one of its ends attached to the first seal means and its other end attached to the

fourth sleeve; said pipe being located outside the four sleeves whereby disconnection of the pipe allows the aforementioned subassembly to be drawn out from the space circumscribed by the third sleeve.

6. The heater of claim 1 and further comprising fluid inlet means mounted on the front closure means in direct connection with one of the passages in the primary heat-absorbing chamber.

7. The heater of claim 1 wherein the first sleeve is provided with an inturned wall section adjacent at least one of its ends; said inturned wall section being capable of deflecting movements incident to thermal elongation of the first sleeve, thereby relieving thermal stress.

8. The heater of claim 1 wherein at least some of the longitudinal partitions are formed as hollow ribs protruding from the sleeves; said hollow ribs being integral with the sleeves so that sleeve fluid or gas flows into the rib hollow spaces.

9. The heater of claim 1 wherein the longitudinal partitions in the secondary hot gas chamber are shorter than the chamber length; successive ones of said last-mentioned partitions being alternately staggered toward or away from the front closure means, whereby the spaces between the end edges of the partitions and adjacent closure means constitute gas flow openings.

10. The heater of claim 1 wherein the partitions between the second and third sleeves comprise three partitions cooperating to define three passages arranged in series flow relation, the first one of the three passages being about 150 radial degrees measured circumferentially, the second one of the three passages being about 120 radial degrees measured circumferentially, and the third one of the three passages being about 90° measured circumferentially.

11. A fluid heater comprising a plurality of telescoping sleeves arranged one within another to define a central hot gas chamber, and a series of annular chambers surrounding said central chamber; at least one of said annular chambers being connected with the central chamber to receive hot gases therefrom; at least one of the annular chambers being adapted to have heat-absorbing fluid flow therethrough; at least some of the annular hot gas chambers and some of the annular fluid chambers having longitudinal partitions therein subdividing same into longitudinal passages, which are in succession connected together at different ends of the heater whereby the hot gases and heated fluid are caused to flow longitudinally back and forth in sinuous paths as they traverse their respective chambers.