March 2, 1965 F. GANZ 3,171,388

HEATING APPARATUS

Filed May 9, 1963 4 Sheets-Sheet 1

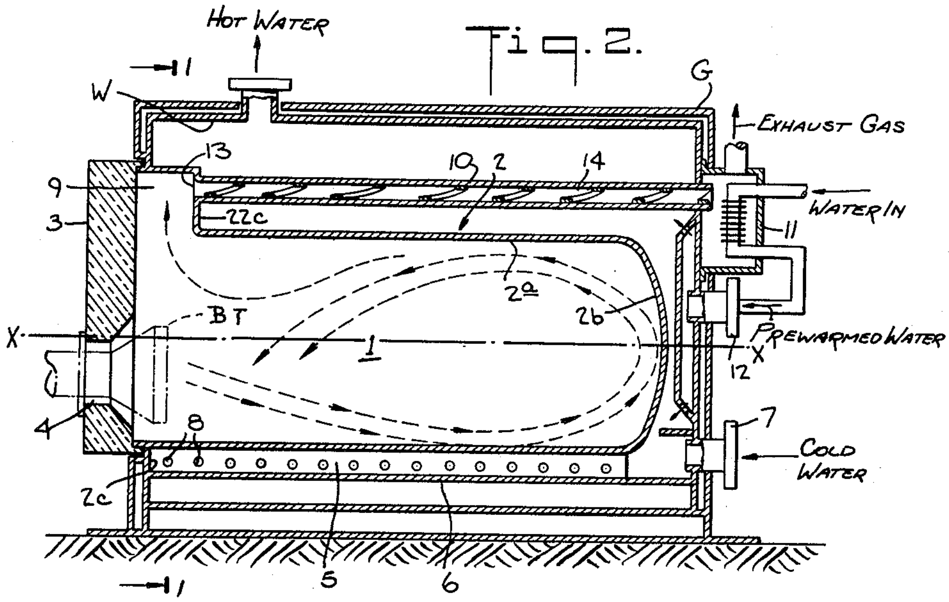

Fig. 2.

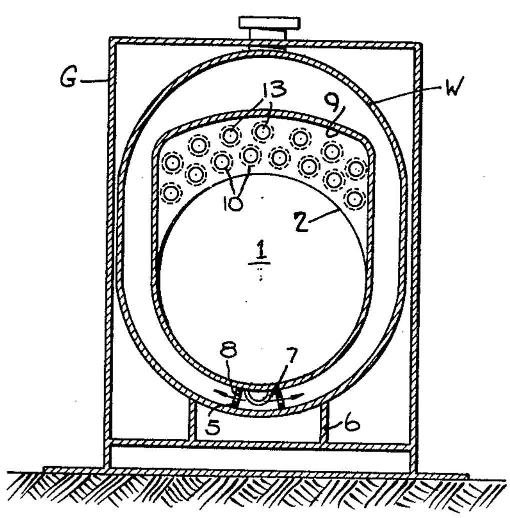

Fig. 1.

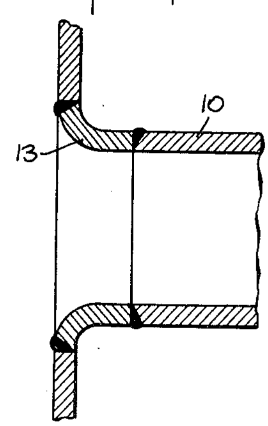

Fig. 3.

INVENTOR.
FELIX GANZ

BY Kenyon & Kenyon
ATTORNEYS

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Fig. 5.

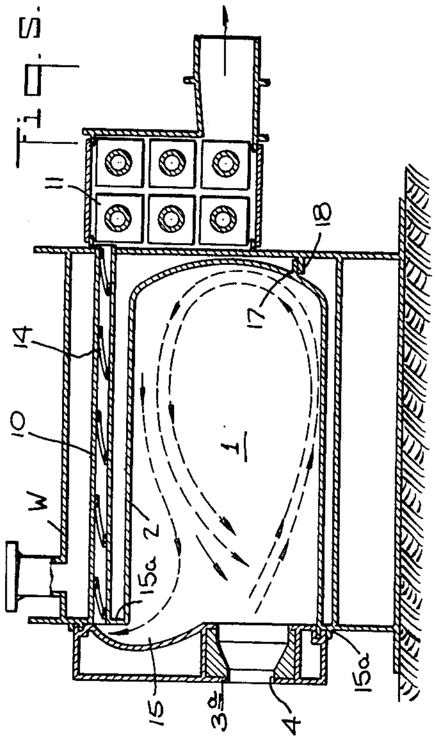


Fig. 7.

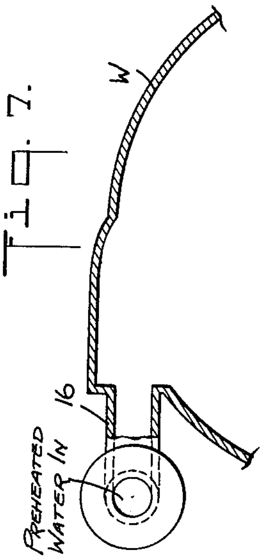


Fig. 4.

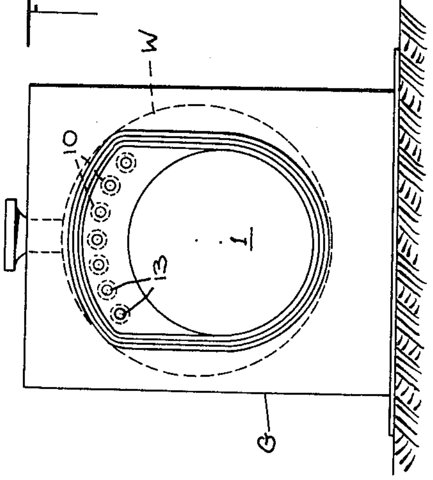
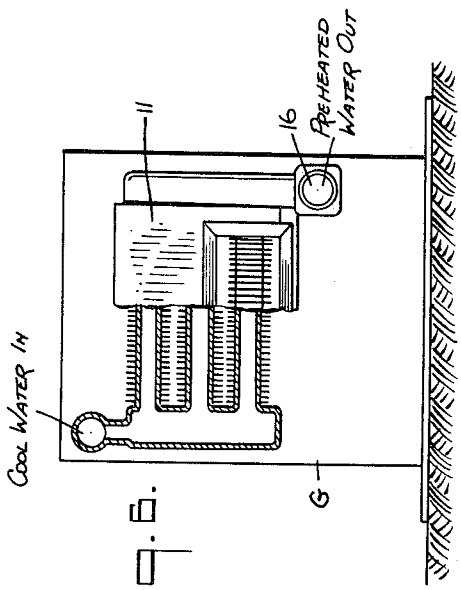


Fig. 6.



INVENTOR.
FELIX GANZ

BY Kenyon & Kenyon
ATTORNEYS

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HEATING APPARATUS

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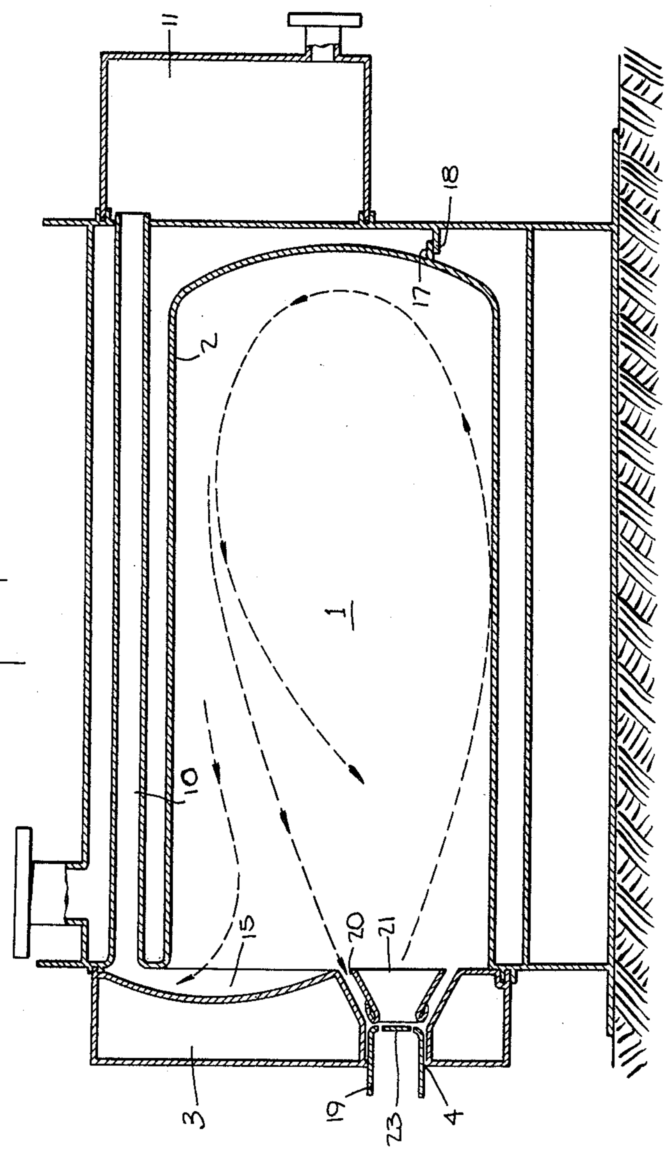

Fig. 3.

INVENTOR.
FELIX GANZ

BY Kenyon & Kenyon
ATTORNEYS

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F. GANZ

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Fig. 9.

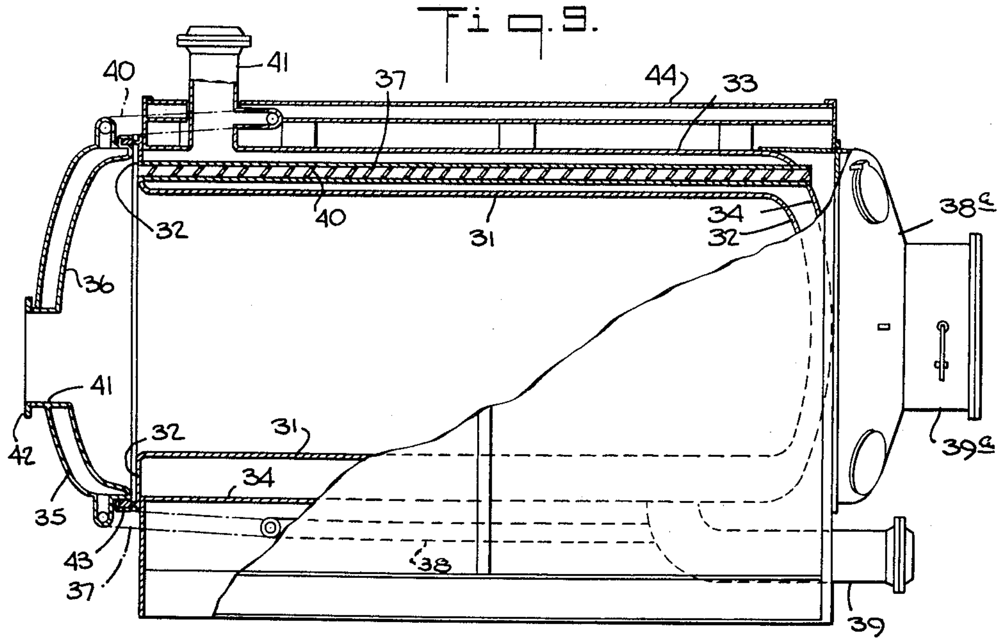
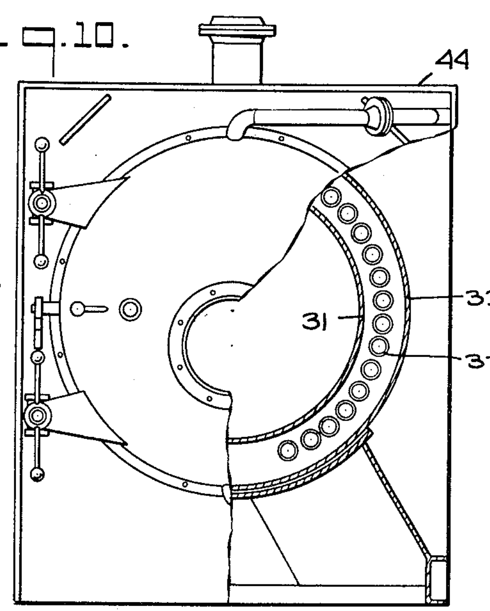


Fig. 10.



INVENTOR
FELIX GANZ
BY
Kenyon & Kenyon
ATTORNEYS

United States Patent Office

3,171,388

Patented Mar. 2, 1965

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3,171,388
HEATING APPARATUS

Felix Ganz, Lucerne, Switzerland, assignor to Ygnis S.A., Fribourg, Switzerland, a stock company of Switzerland

Filed May 9, 1963, Ser. No. 279,048
Claims priority, application Switzerland, Oct. 10, 1956, 38,346
13 Claims. (Cl. 122—149)

The present application is a continuation-in-part of application Serial Number 691,117 filed October 7, 1957, entitled Method of Burning Fluid Fuels and Heater for Utilizing Such Method.

This invention relates to furnaces in general. It is concerned particularly with a water heating boiler for providing hot water or steam to the heating systems of buildings.

A water heating boiler when fired by an oil or gas burner injects the fluid fuel together with a flow of air under pressure into a fire box having a water jacket which surrounds the fire box with the water to be heated. The fire box is made of metal such as steel or iron. Where the flame from the burner impinges on the fire box directly, nonmetallic refractory elements are used which, when heated adequately, tend to promote more thorough burning of the fuel while serving to protect the metal from the flame.

When the fire box has a cylindrical contour, the prior art teaches that the burner should be located on the axis of the fire box so that the flame contour substantially coincides with the shape of the fire box and is kept from direct impingement therewith excepting at the end of the fire box remote from the burner where the nonmetallic refractory is placed to assist in obtaining more complete combustion and so as to protect that end of the fire box against direct flame impingement. A number of exhaust flues may be arranged as an arcuate series arranged concentrically with respect to the cylindrical side wall of the fire box with entrances connecting with the latter adjacent to its burner and with these flues extending through the water space formed by the water jacket, the flues having exhaust exists adapted for connection with a stack or chimney.

The above has the disadvantage that even with the use of the nonmetallic refractory for assisting the combustion of the fuel, incomplete combustion is not unusual. The nonmetallic refractory is expensive to install and it forms undersired thermal insulation between the flame and the wall of the combustion chamber, this interfering with the transfer of heat from the flame and its resulting hot gases to the water surrounding the fire box. Particularly when made large enough to have the capacity required for heating large buildings, there is a problem in getting the flue gases up the stack or chimney into the atmosphere, ordinarily solved expensively by providing a large capacity stack or flue or resorting to the use of a mechanically forced draft requiring blowers or fans. In spite of the described precautions the fire box may be subjected to hot spots resulting in premature fire box failure. Because the heating efficiency is undesirably low the physical size of such a conventional water heating boiler must be made undesirably large as related to the heating capacity obtained.

The object of the present invention is to provide an improved heating apparatus the principles of which are particularly applicable to a water heating boiler when fired by an oil or gas burner of the previously described kind, although these principles may be applied otherwise. More specifically, it is desired to eliminate the need for the nonmetallic refractory used usually, to permit the use of a stack or chimney of reduced size as compared to that required conventionally and without using mechanical forced draft expedients, to reduce the problem of hot spots forming in the fire box and to provide for an increased efficiency permitting a reduction in the physical size of a water heating boiler as compared to the size of the conventional boiler of corresponding heating capacity.

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A heating apparatus made in accordance with the present invention features an enclosure or fire box formed by a substantially cylindrical side wall and interspaced end front and back walls. The front wall may be a door providing internal access for the removal of soot, for example. Means are provided for introducing a flow of hot gas in the enclosure flowing backwardly from the front wall mainly on one side of the axis of the side wall and which is looped forwardly by the back wall to then flow forwardly mainly on the opposite side of the side wall's axis towards the front wall of the enclosure or fire box. Flues are provided for exhausting the hot gas at or adjacent to the front wall.

Further, the exhausting means is constructed with a flow capacity choking the exhaust flow therethrough. This causes the atmospheric pressure within the enclosure or fire box to increase because of the introduction of the flow of hot gas.

Two particularly desirable effects result from the foregoing principles. One is that the gas after being looped forwardly and while flowing forwardly does not all exhaust through the exhausting means but instead loops a second time, this time in a backward direction, so as to rejoin the hot gases being introduced. When the hot gas introducing means is in the form of a fluid fuel burner using air under pressure of theoretically the proper amount for complete combustion, although complete combustion might not ordinarily occur prior to exhausting to the stack, the hot gases and unburned fuel and air in this case are reintroduced to the hottest part of the flame, thereby promoting complete combustion without using the customary nonmetallic refractory elements for this purpose. The other advantage is that the fire box may be operated at superatmospheric pressure so that the flue gases exhaust under this pressure so as to travel to the outer atmosphere even though a smaller than usual stack or chimney is provided.

Because the fire box of this invention proivdes for a whirling substantially closed loop of flame and hot gases within the fire box the danger of hot spots is reduced or eliminated. Rapid heat exchange between the flame and hot gases and the fire box is promoted. There is no need for the undesirable thermal insulating effect necessarily incidental to the use of nonmetallic refractory elements. The cost of such elements is eliminated.

In this invention the fluid fuel burner location departs from concentricity with the axis of the cylindrical side wall of the fire box which is the obvious location because it is what is taught by the prior art literature and engineering practices. Instead, the burner is installed through the front end wall of the enclosure or fire box at a location between the latter's axis and its periphery. In other words, this location is offset from this axis. The degree or distance of this offset may be varied but as a minimum it should be sufficient to assure that the flame is introduced mainly on one side of the axis of the enclosure or fire box. The offset must be sufficient to provide room on the other side of the axis for the return or forward flow resulting when the injected flame and hot gases are looped forwardly by the back end wall.

The flow resistance to the whirling loop of flame and hot gases maintained within the fire box is reduced by making one or both of the two end walls more or less concave internally. With the front end wall, which may be the door, having at least a portion that is concave the fire box's interior may use this concave portion as a passageway to the entrances to the flues described previously. In such an instance the door may be made hollow and water cooled in the customary manner and the water used may be part of the body of water maintained in the water jacket around the fire box so as to prevent heat loss. Otherwise, such as in the case of smaller units, the door may be solid and made with a suitable refractory interior.

Specific examples of water heating boilers embodying the foregoing and other principles of the present invention are illustrated by the accompanying drawings in which:

FIG. 1 is a vertical cross section taken on the line **1—1** in FIG. 2;

FIG. 2 is a longitudinal section of a first example of the water boiler;

FIG. 3 is a longitudinal section on enlarged scale showing the entrance to one of the flues;

FIG. 4 is an end elevation of a second example with the door or front end wall removed;

FIG. 5 is a longitudinal section taken on a vertical plane of the example shown by FIG. 4;

FIG. 6 is a partially broken away back end view of the second example;

FIG. 7 shows partly in elevation and partly in transverse cross section the water inlet to the water boiler forming this second example;

FIG. 8 is a longitudinal section taken on a vertical plane showing a third example;

FIG. 9 shows partly in elevation and partly in longitudinal section taken on a vertical plane, a commercial form of the present invention; and

FIG. 10 is a front view partly in elevation and partly in cross section of the form shown by FIG. 9.

Of these drawings, FIGS. 1–8 are somewhat schematic. They are intended to illustrate the fundamental principles of the invention.

Referring first to FIGS. 1–3 in this first example the combustion chamber space **1** is defined by the fire box **2** which has a cylindrical side wall **2***a*, which is considerably longer than its diameter, and a back end wall **2***b* that is concavo-convex with its concave side facing inwardly. This fire box **2** may follow the usual practice insofar as it is made from a suitable metal in the form of a shell having the back end wall which is generally dome shaped so as to form a cuplike structure. The fire box may be made from steel or iron and its wall thickness need not be very great as compared to its lateral extent. The fire box interior does not contain any nonmetallic refractory element or the like at or adjacent to the end wall **2***b*. The fire box's inside surface is entirely open to the flame and hot gases.

This fire box **2** is surrounded by a water jacket W and the fire box connects with the water jacket at the front end of the fire box by wall members **2***c* which extend in a generally radial direction outwardly so as to join with the outer wall of the water jacket, the latter's inner wall being the fire box itself. The front of the fire box **2** is closed by a door **3** which provides the front end wall of the combustion chamber **1**. This door may be solid or hollow and water cooled.

Like the examples described hereinafter, the present example is a water boiler heater of the horizontal type. The lower portion of the door **3** is provided with a port **4** adapted to receive the burner tube BT of an oil or gas burner of the type provided with a blower for providing a blast of air under pressure intended to be adequate to support combustion of all of the fuel supplied. The fluid fuel is ordinarily ejected by the burner under pressure also in the form of one or more jets and, of course, a suitable igniter is normally included by such a burner. The burner should be fitted to the port so as to prevent the escape of gases from the combustion chamber.

The burner tube BT is indicated schematically by broken lines in FIG. 2, and the axis of the cylindrical side wall **2***a* of the fire box is shown by a broken line marked X—X. It can be seen that the burner tube BT is located substantially entirely below or practically completely offset radially from this axis. The port **4** is, of course, located correspondingly as must be the burner, mounted to the door, providing the burner tube.

As previously indicated, the distance the burner is offset from the axis of the cylindrical side wall of the fire box may be varied providing the previously described effect is achieved. According to the prior art the burner should be located so as to inject its flame into the fire box as exactly at the axis as manufacturing precision makes possible. To achieve the action of the present invention the burner must be offset definitely from this axis a distance sufficient to make sure that the main portion or a majority of the flame and the resulting hot gases flow through the fire box on one side of the centerline of the fire box's cylindrical side wall **2***a*, then loop forwardly by deflection caused by the concave inner surface of the fire box's end back wall **2***b*, and then to flow forwardly on the opposite side of the axis from that where the backward flow occurs. The location of the burner should be such as to avoid the flame and hot gases impinging the back end wall **2***b* substantially centrally so as to more or less uniformly fan out in all radial directions. Such an action would require the use of nonmetallic refractory elements for protecting the end back wall and to maintain ignition of the fuel.

Although the front end of the fire box is interconnected in a substantially rigid manner with the corresponding end of the water jacket W as previously described, the rest of the fire box is free to expand and contract. In effect, the rest of the fire box floats within the water confined by the water jacket. This freedom to expand and to contract with the backwardly projecting fire box forming in effect a cantilever, need not be interfered with even though the fire box is additionally supported. For example, the cylindrical side wall of the fire box may be supported by a pedestal **5** of downwardly spreading V-shaped cross sectional contour which bears on the bottom wall of the water jacket W which is in turn supported by base member **6**. However, the pedestal should have a freely movable relationship with respect to the bottom wall of the water jacket W so that the fire box remains free to expand and contract throughout its portions not connected to the water jacket. Such expansion and contraction may be caused by thermal influences.

The cold water returning to the furnace from the heating system for reheating, enters the water jacket through an inlet **7** with the flow going between the two legs of the pedestal **5**. These two legs, in the form of elongated plates, are provided with a series of holes **8** formed through them transversely so that the water enters the lower portion of the water jacket from these holes. This introduces a whirling action to the water promoting the heat transfer between the outside of the fire box **2** and the water. The flow of water circumferentially around the fire box keeps the water in the water jacket moving at all times.

The front end of the fire box **2** is shaped to form an upstanding dome **9** and two generally arcuate series of flues **10** have their entrances connected with or opening from this dome **9**. The two series are superimposed radially with respect to the axis of the fire box **2**. These flues extend longitudinally backwardly from the dome **9** through the water space formed by the water jacket W. The back ends of the flues pass through the wall of the water jacket so as to open into an economizer **11**. Some of the cold water returning from the heating system may be passed through this economizer **11** and introduced into the water jacket by way of the inlet **12**. The back ends of the flues could open directly to a connection with the stack or chimney.

The flues **10** are connected to the dome **9** through flaring funnel-like entrance members **13** which are welded or brazed to the vertical wall of the dome 9 and to the tube 10 in each instance as shown by FIG. 3. These connections 13 are in the form of flaring members which reduce the flow resistance while having the further advantage that when a flue, which is in the form of a tube, has to be changed the necessary separation and subsequent rejoining may be effected at the points of the welds or brazes of the connections 13 without damaging the adjacent portions of the wall of the fire dome.

As previously indicated, the overall or total flow capacity of the fllue tubes 10 are related to the volume of the hot gas created in the fire box by the burner tube BT so as to cause the atmospheric pressure in the fire box to be maintained higher than atmospheric pressure. In the commercial form of the device the flue gas pressure does not drop to atmospheric pressure until the flue gas exits from the flue tubes.

The return or forward flow of the looped hot gases does not all escape through the flue tubes. These forwardly flowing gases, normally containing a substantial amount of unburned fuel, loop backwardly or reversely adjacent to the front end wall or door 3 so as to rejoin the flow created by the flame injected into the fire box by the burner tube BT.

The result of the off center burner tube location possibly aided by the above is the whirling loop of flame the path of which is indicated schematically by broken lines and arrowheads in FIG. 2. The entire fire box is filled substantially uniformly with this whirling closed loop of flame and hot gases. Because of the recirculation there is adequate time for complete combustion and reignition when necessary is constantly effected by the flame injected by the burner tube BT. Because of the flame motion the metal wall of the enclosure 2 is constantly wiped by the flame and hot gases with the temperatures existing within the various zones of the fire box 2 remaining relatively constant as compared to prior art furnaces.

The need for nonmetallic refractory elements is eliminated because their normal function of maintaining ignition by being heated to incandescence is supplied by the reintroduction of the flow to the burner's flame just beyond or leaving the burner tube. The need for such refractory elements to prevent direct flame impingement is eliminated because the whirling loop of flame has approximately a constant temperature throughout the interior of the fire box 2. Instead of impinging directly against the concave inside of the fire box's back end wall, the flame rotates or turns at this point as it is not only forced forwardly by its looping action, but drawn in that direction by the action of the flame injected by the burner. The relatively high pressure within the fire box keeps the flame from concentrating locally at any place.

In effect the flame assumes an elongated egg shaped pattern of continuously moving flame, hot gases and unburned fuel particles or gases. This flame pattern is continuously kept in motion by the action of the injected flame. The arrows and broken lines shown in FIG. 2 represent to some extent the pattern formed by the unburned fuel, particularly in the case of oil. The entire fire box is filled with the flame and hot gases.

All of the flue tubes are connected through the economizer 11 with a common exhaust port or duct which may be connected to the stack or chimney. Because of the pressure existing in the fire box the stack gases need not be sucked from the fire box, thereby eliminating the need for an expensive large size stack or chimney or mechanical forced draft expedients.

Practical experience with the commercial form of the furnace has shown that when burning heavy grades of furnace oil little soot or coke is found in the enclosure 2. This indicates the practically complete combustion obtained even though the usual nonmetallic refractory elements normally provided to maintain ignition and promote combustion, are not used.

Since the flue tubes 10 pass through the water in the water jacket, a large amount of the flue heat is recovered directly. To prevent laminar flow through these tubes flow agitation members may be used such as helical wire elements indicated at 14. Due to the efficiency of this heat recovery economizer 11 may at some times present the disadvantage that the existing flue gases are so cold as to drop to a temperature below their dew point temperature. Then the economizer need not be used.

In the example shown by FIGS. 4–7, the parts that correspond with the parts of the first example are given corresponding numerals. The difference is that the door *3a* is formed with an interior surface that includes an inwardly facing concave portion 15. This eliminates the need for the dome 9 of the first example. The fire box 2 extends fully forwardly and joins with the water jacket W by way of a radially extending wall portion *15a* and the entrances to the flues 10 open into this wall portion. The concave portion 15 of the door extends radially far enough to overlap the entrance to the tubes 10 and thereby form a passageway leading to these tubes.

As shown by FIG. 4 only a single arcuate series of interspaced flue tubes 10 is provided. In this series the tubes are arranged to form a pattern that is a segment of a cylinder which is substantially concentric with respect to the axis of the fire box 2. It follows that the concave portion 15 can be made more extensive and so as to embrace the entire inside of the door 3 to provide an internal cavity generally corresponding to that of the back end wall of the fire box but having an adequately large radius to overlap the entrances to the flue tubes. Correspondingly, the arcuate series of flue tubes can be extended until a circular series is formed which completely surround the fire box. In such a case the individual inside diameter of each flue tube is proportioned so that the total flow capacity of all the tubes as related to the capacity of the burner, may be adjusted to maintain the superatmospheric pressure within the fire box and flue tubes. With a larger number of flue tubes a larger burner may be used.

In this second example, the pre-heated water from the economizer is injected into the water jacket W by a tangential inlet 16 so as to obtain a whirling action of the water for the purpose described previously. If the economizer is eliminated the cold water returned from the heating system may be introduced to the water jacket through this inlet 16.

As in the first example, only the front end of the fire box 2 is rigidly connected to the water jacket, the fire box more or less functioning as a cantilever within the water jacket. As additional support the fire box has a rear extension 17 which is supported loosely on a member 18 connected to the water jacket.

In this second example the door is more directly affected by the hot gases within the furnace and, therefore, it may be water cooled. Conveniently this is done by making the door hollow and connecting its interior through flexible connections with the water in the water jacket, this not only preventing overheating of the door but preventing loss of heat by exchanging it with the water.

In all of the examples described hereinbefore the burner has been shown as being located below the axis of the cylindrical side wall of the fire box. The new operation can be obtained regardless of the location of the burner providing that it is offset from the axis of the cylindrical side wall of the fire box 2 enough to cause the injected flame and hot gases to travel backwardly into the fire box mainly on one side of the latter's axis and to then move forwardly and flow forwardly mainly on the other side of this axis. Then the forwardly traveling flame and hot gases rejoin with the flame injected into the furnace. It follows that the burner could be located above the axis or horizontally offset from the axis and the principle of operation could be applied to a vertically arranged fire box and water jacket if desired providing the offsetting of the burner is effected to an adequate degree. The principle of operation described hereinabove might be applied even to a coal burning furnace providing an adequate blast of hot air is furnished over the grate so as to obtain the closed looped whirling action of the hot gases.

Experience with prior art furnaces burning oil have shown that the heated surfaces are sooted to a high degree and that sulphur may be deposited so as to promote corrosion trouble. This has led to suggestions that some of the waste gases should be returned to the burner directly at the source of the flame so that the fine soot particles of the hot gas produced by the flame can combine with the sulphur compounds and reduce the trouble.

With the above in mind, in the example or modification shown by FIG. 8 the burner tube **19** of the oil burner is inserted through the port **4** in the door **3** the latter being either made with a nonmetallic refractory or made hollow and adequately water cooled as previously described. The burner port is made with a funnel-shaped enlargement **20** which is located in front of the tube **19** and a funnel **21** is made of suitable refractory and located in the enlargement **20** in spaced relation therewith. This part **21** therefore leaves space through which a portion of the hot gases present in the combustion chamber **1** formed by the fire box **2**, is conducted. This may be either because of the excess pressure in the fire box or by an aspiration action produced by operation of the flame in the vicinity of the ports **23**.

In the above fashion a portion of the hot gases is drawn directly to the burner for reintroduction to the furnace, as shown by the arrow diagram in FIG. 8. The amount of waste gases or other atmosphere from within the fire box thus introduced to the source of the flame may be regulated by axially moving the burner tube **19** in any suitable manner.

The foregoing is substantially the same disclosure as was in the original application Serial Number 691,117.

The commercialized form of the invention is shown by FIGS. 9 and 10 and the transition from the original forms of the invention to this commercial form are apparent.

Referring now to FIGS. 9 and 10, the combustion chamber is formed by the fire box having the cylindrical side wall **31** and, while only partly shown, the concavo-convex back wall **32** previously described. This fire box is made of metal with a smooth interior and is free from any interior nonmetallic refractory elements. The water jacket **33** encloses the fire box in the form of a second cylinder concentric with the cylindrical side wall **31** of the fire box and a back wall **34** that follows generally the contour of the end back wall **32** of the fire box. In other words, there are interspaced inner and outer cylindrical side walls and inner and outer concavo-convex end walls both formed from metal of about the same thickness that is used by prior art water heating boilers.

The front end of the fire box's cylindrical wall **31** has a radial wall **32** which is a common wall with respect to the water jacket and which interconnects the two rigidly. The rest of the fire box extends into the water from this wall **32** in the form of a cantilever. Therefore, the fire box is entirely free to contract and expand as required. The door is formed by an outer wall **35** and an inner wall **36** having a completely concave inside. The door is sufficiently greater in diameter than the diameter of the fire box to overlap the wall **32** a substantial amount. The interior of this door is hollow to form a water-cooled door, the walls **35** and **36** being joined together at their peripheries.

The bottom or lower portion of the door connects through a flexible tube **37** with an extension pipe **38** connecting with the boiler's water return connection **39**, the latter connecting with the water space between the fire box's walls and the water jacket's walls. The top or upper portion of the door connects through a flexible tube **40** with the boiler's output connection **41** which leads from the water space. Both tubes **37** and **40** connect with or open into the water space between the door's walls **35** and **36**.

Note that the concave inside **36** of the door corresponds to the concave section **15** shown by FIG. 5, excepting that now there is complete concavity throughout the door. The flue tubes **37** in this form are, therefore, made as a completely circular series surrounding completely the fire box's wall **31** and substantially concentric therewith. The inlets or entrances to these flue tubes receive the waste gases by way of the peripheral passage formed by the concavity of the door's inner wall **36** and they exhaust into a manifold **38**_a_ which connects them with a common stack or chimney connection **39**_a_. Each tube **37** contains a helical wire flow turbulating member **40** which may be pulled forwardly from the tube in each instance when the door is opened.

The burner port **41** is shown as being located almost completely offset from the axis of the cylindrical side wall of the fire box. The latter has a length approximately twice its diameter and in any event this length should be substantially longer than the diameter of the fire box's side wall. The port **41** is, of course, adapted to receive the burner tube of a standard oil burner having a blower or fan for injecting the air under pressure, and usually the oil is injected under pressure. A flange **42** serves to mount the oil or gas burner unit on the door and the latter closes gas-tightly by reason of a seal **43** on the door frame.

Although not previously mentioned in the preceding examples, a case or protective or decorative covering **44** encloses the water jacket and in the case of the commercial form this water jacket casing or protector **44** is shown. This may have a rectangular shape and it may encase thermal insulation surrounding the water jacket.

With the door provided with the substantially gas-tight seal **43**, the burner installed to the door may have adequate capacity so that the circular series of flue tubes **37** exert a choking action and produce the superatmospheric pressure within the combustion chamber. Because of the circular side wall and the concave surface of the end back wall and the end front wall, provided by the door, together with the axially offset relationship of the port **41**, the whirling mass of flame and hot gases is produced. The flow is in the form of a closed loop or egg-shaped mass of hot flame and hot gases following closely all of the inside surfaces of the combustion chamber. Exhaust is effected around the entire periphery of this flame by way of the annular series of flue tubes **37**. The latter give up some of the heat of the flue gas to the water confined by the water jacket around the fire box.

One closed loop would not ordinarily provide for complete combustion of the oil but the unburned oil is reintroduced to the oil burner's flame at the end of the first looped circuit and continuously thereafter. There is no chance for the flame to lose ignition heat because it is continuously reintroduced to the oil burner's flame. Conventional oil burners introduce a relatively high velocity flame so the velocity of the whirling closed loop of hot flame and gases existing within the fire box has relatively high velocity. The entire inner surface of the fire box is wiped continuously by flame and hot gases of relatively uniform temperature throughout the entire inner surface of the walls defining the combustion chamber.

For equal heating capacity the water heating boiler shown by FIGS. 9 and 10 when compared to prior art boilers of comparable heating capacity, require substantially a smaller amount of space. Any stack or chimney to which the flue gas outlet **39** is connected receives the gas under at least some pressure above atmospheric or at least at atmospheric pressure and obtains the advantages previously described. Although the formation of soot and carbon is largely avoided, cleaning of the fire box is effected easily by opening the door.

The fire box is entirely free from fire brick or other nonmetallic refractory elements such as are usually required to maintain ignition and protect the metal fire box against direct flame impingement. Opening of the door exposes all of the flue tubes so that the wire elements 37 may be pulled out for cleaning.

The heat recovery effected by reason of the circular series of flue tubes extending directly through the water is so efficient that no economizer is needed. As previously indicated, an economizer might result in an undesired excessive drop in the temperature of the exhausting flue gas.

It can be seen that the main difference between the commercial form and the originally disclosed forms of the present invention is the extension of the concavity 15 shown by FIG. 5 so as to make this concavity embrace the entire door, and the extension of the partly circular series of flue tubes shown originally, to form a completely circular series. The transition of the first form to the present commercial form has involved no departures and this commercial form is now in extensive successful use commercially.

The water jacket at its back end may be supported by a saddle 45 mounted by legs 46. This may be done loosely to permit expansion and contraction, the water jacket otherwise being supported only at its front end by the case 44 which may be made structurally strong for this purpose. Although not shown, the fire box may be supported at its back end loosely as described before. When the water jacket is empty this support of the fire box may be desirable.

What is claimed is:

1. A fluid heater including a fire box formed by a substantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicating with the shell's interior and having an exhaust exit for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box.

2. In a furnace, in combination, an elongated cylindrical combustion chamber having a horizontal longitudinal axis and two end walls extending transversely of said axis; a shell surrounding said combustion chamber and forming a water jacket therewith; burner means communicating with said combustion chamber at one of the end walls thereof at a part of said one end wall spaced from said axis for projecting a flame into said combustion chamber longitudinally thereof, said burner means during operation providing an endless stream of combustion materials circulating in said chamber; and a fire tube in said water jacket extending parallel to said axis and communicating with said combustion chamber adjacent said one end wall thereof at a part spaced from said burner means on the side of said axis opposite from said burner means, said tube providing restricted outlet means for discharging only a portion of said combustion materials from said stream out of said chamber, whereby another portion of said materials returns to said stream, said furnace further including a base member, a support member movable on said base member, said combustion chamber being mounted on said support member.

3. In a furnace, in combination, an elongated cylindrical combustion chamber having a horizontal longitudinal axis and two end walls extending transversely of said axis; a shell surrounding said combustion chamber and forming a water jacket therewith; burner means communicating with said combustion chamber at one of the end walls thereof at a part of said one end wall spaced from said axis for projecting a flame into said combustion chamber longitudinally thereof, said burner means during operation providing an endless stream of combustion materials circulating in said chamber; and a fire tube in said water jacket extending parallel to said axis and communicating with said combustion chamber adjacent said one end wall thereof at a part spaced from said burner means on the side of said axis opposite from said burner means, said tube providing restricted outlet means for discharging only a portion of said combustion materials from said stream out of said chamber, whereby another portion of said materials returns to said stream, said furnace further including a base member, a hollow support member in said water jacket movable on said base member, said combustion chamber being mounted on said support member, said support member maintaining said combustion chamber spaced from said shell and being formed with a plurality of openings for admitting water from said hollow support member to said water jacket.

4. In a furnace, in combination, an elongated horizontal combustion chamber; an outer shell substantially coextensive with and surrounding said chamber, said shell forming a water jacket with said chamber and said shell being spaced at all parts from said chambers; an elongated channel member extending longitudinally along the bottom of said combustion chamber and supporting the latter, said channel member having side walls extending downwardly from said combustion chamber to said shell and said channel member extending along the entire length of said shell and said combustion chamber, said side walls being formed with openings passing therethrough; and conduit means communicating with the interior of said channel members for supplying a liquid to the interior thereof to flow through said openings into said jacket, whereby said channel member in addition to serving as a support for said combustion chamber in said shell also serves to distribute water into the water jacket.

5. In a furnace, in combination, an elongated cylindrical combustion chamber having a horizontal longitudinal axis and two end walls extending transversely of said axis; a shell surrounding said combustion chamber and forming a water jacket therewith; burner means communicating with said combustion chamber at one of the end walls thereof at a part of said one end wall spaced from said axis for projecting a flame into said combustion chamber longitudinally thereof, said burner means during operation providing an endless stream of combustion materials circulating in said chamber; and a fire tube in said water jacket extending parallel to said axis and communicating with said combustion chamber adjacent said one end wall thereof at a part spaced from said burner means on the side of said axis opposite from said burner means, said tube providing restricted outlet means for discharging only a portion of said combustion materials from said stream out of said chamber, whereby another potrion of said materials returns to said stream, said one end wall of said combustion chamber being in the form of a fire door and said door being formed with a duct providing communication between the interior of said chamber and said fire tube so that gases flow from the interior of said chamber through said duct of said fire door to said fire tube.

6. A fluid heater including a fire box formed by a substantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between

the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicating with the shell's interior and having an exhaust exit for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box; said pressure causing a portion of said forward flow to join with said backward flow to form a whirling closed loop of burning fluid fuel and gas within said fire box, said burner means introducing said flow substantially directly into the end of said shell at a location at least adjacent to said front end wall and causing said closed loop to substantially entirely fill said fire box.

7. A fluid heater including a fire box formed by a substantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicating with the shell's interior and having an exhaust exit for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box; said flue means including at least one flue tube extending through said jacket enclosure for substantially the length of said shell, at least a portion of the inner surface of said end front wall forming a space extending from said shell and connecting with the end of said flue tube adjacent to the end front wall to form entrance to the flue means.

8. A fluid heater including a fire box formed by a substantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicating with the shell's interior and having an exhaust exit for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box; said flue means including at least one flue tube extending through said jacket enclosure for substantially the length of said shell; said flue entrance being formed by a chamber extending laterally from the end of said shell adjacent to said end front wall and open to the inside of said shell and to the end of said tube adjacent to the end front wall.

9. A fluid heater including a fire box formed by a substantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicating with the shell's interior and having an exhaust exit for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box; said pressure causing a portion of said forward flow to join with said backward flow to form a whirling closed loop of burning fluid fuel and gas within said fire box, said burner means introducing said flow substantially directly into the end of said shell at a location adjacent to said front end wall and causing said closed loop to substantially entirely fill said fire box; said flue means including at least one flue tube extending through said jacket enclosure for substantially the length of said shell, at least a portion of the inner surface of said end front wall forming a space extending from said shell and connecting with the end of said flue tube adjacent to the end front wall to form said entrance to the flue means.

10. A fluid heater including a fire box formed by a substantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicating with the shell's interior and having an exhaust exit for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box; said pressure causing a portion of said forward flow to join with said backward flow to form a whirling closed loop of burning fluid fuel and gas within said fire box, said burner means introducing said flow substantially directly into the end of said shell at a location adjacent to said front end wall and causing said closed loop to substantially entirely fill said fire box; the inner surface of at least said end back wall being substantially concave and reducing the flow resistance to said whirling closed loop.

11. A fluid heater including a fire box formed by a substantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicat-

ing with the shell's interior and having an exhaust exit for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box; said pressure causing a portion of said forward flow to join wtih said backward flow to form a whirling closed loop of burning fluid fuel and gas within said fire box, said burner means introducing said flow substantially directly into the end of said shell at a location adjacent to said front end wall and causing said closed loop to substantially entirely fill said fire box; the inner surface of said end back wall being substantially concave, said flue means including a plurality of flue tubes extending through said jacket enclosure for the length of said shell, said end front wall having a concave inner surface open to said shell and to the ends of the flue tubes adjacent thereto and forming said entrance to said flue means, said concave surfaces reducing the flow resistance to said whirling closed loop of burning fluid fuel and gas.

12. A fluid heater including a fire box formed by a substantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicating with the shell's interior and having an exhaust exit for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box; said pressure causing a portion of said forward flow to join with said backward flow to form a whirling closed loop of burning fluid fuel and gas within said fire box, said burner means introducing said flow substantially directly into the end of said shell at a location adjacent to said front end wall and causing said closed loop to substantially entirely fill said fire box; said closure forming said end front wall being hollow, and means for conducting fluid from said jacket enclosure through said hollow closure.

13. A fluid heater including a fire box formed by a susbtantially cylindrical shell having a length greater than its diameter and having an end back wall, a closure forming an end front wall for said enclosure, fluid fuel burner means mounted through said closure at a location between the axis of said shell and its periphery and directing a flow of burning fluid fuel and gas flowing backwardly towards said back wall mainly on one side of this axis and which is looped forwardly from the back wall and flows forwardly mainly on the opposite side of this axis, a jacket enclosure for said shell and its back wall for surrounding the latter and the shell with the fluid to be heated, and flue means having an entrance at least adjacent to said end front wall and communicating with the shell's interior and having an exhaust exist for connection with the outer atmosphere, the total flow capacity of said flue means being related to the capacity of said burner to form hot gases from said burning fluid fuel within said fire box, to maintain a superatmospheric pressure within the fire box; said pressure causing a portion of said forward flow to join with said backward flow to form a whirling closed loop of burning fluid fuel and gas within said fire box, said burner means introducing said flow substantially directly into the end of said shell at a location adjacent to said front end wall and causing said closed loop to substantially entirely fill said fire box; the inner surface of said end back wall being substantially concave, said flue means including a plurality of flue tubes extending through said jacket enclosure for the length of said shell, said end front wall having a concave inner surface open to said shell and to the ends of the flue tubes adjacent thereto and forming said entrance to said flue means, said concave surfaces reducing the flow resistance to said whirling closed loop of burning fluid fuel and gas; said closure forming said end front wall being hollow, and means for conducting fluid from said jacket enclosure through said hollow closure.

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PERCY L. PATRICK, *Primary Examiner.*

KENNETH W. SPRAGUE, *Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,171,388

March 2, 1965

Felix Ganz

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 1, line 42, for "exists" read -- exits --; line 48, for "undersired" read -- undesired --; column 2, line 45, for "proivdes" read -- provides --; column 5, line 11, for "fllue" read -- flue --; line 69, after "that" insert -- even --; column 6, line 6, for "existing" read -- exiting --; column 6, line 28, for "cavity" read -- concavity --; column 10, line 64, for "potrion" read -- portion --; column 11, line 48, before "entrance" insert -- said --; column 14, line 15, for "exist" read -- exit --.

Signed and sealed this 17th day of August 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents