March 30, 1965 M. DUBIN ETAL 3,175,540

HOT WATER BOILER

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FIG. 1

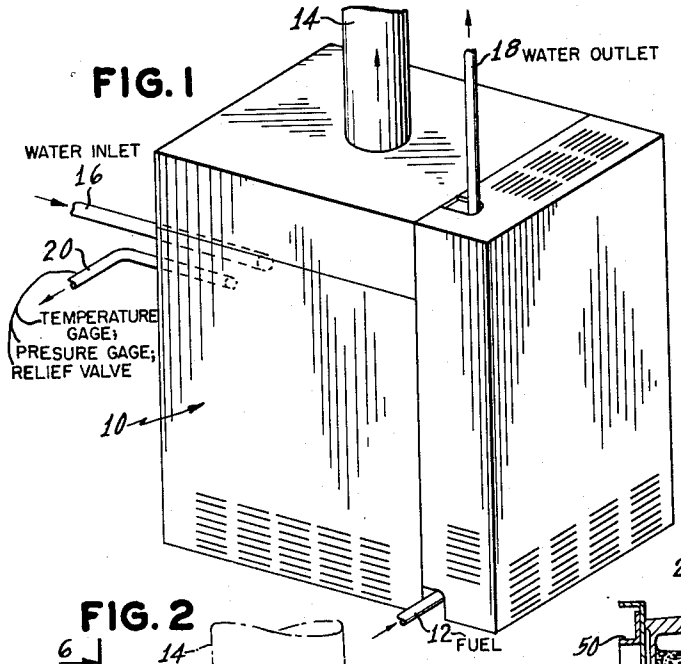


FIG. 3

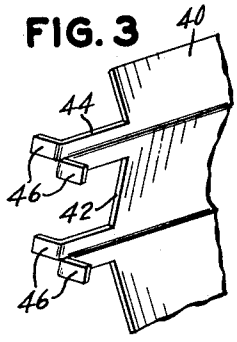


FIG. 2

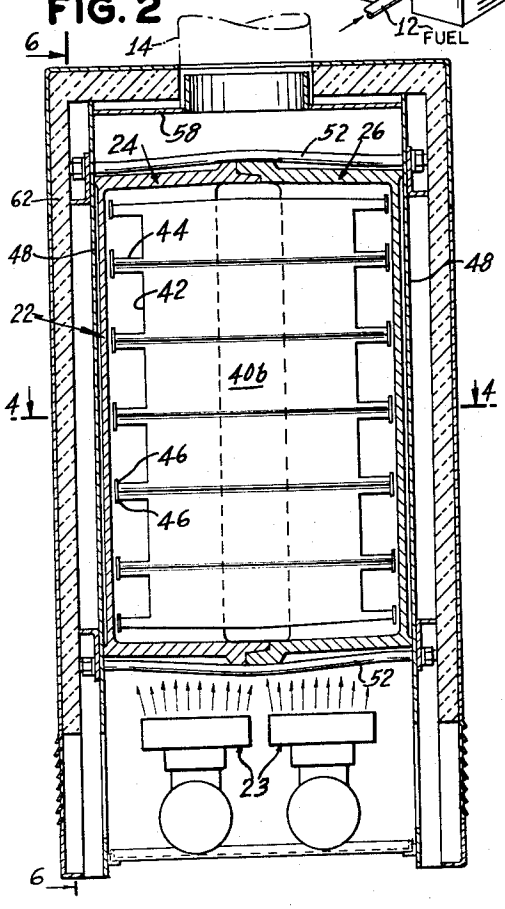
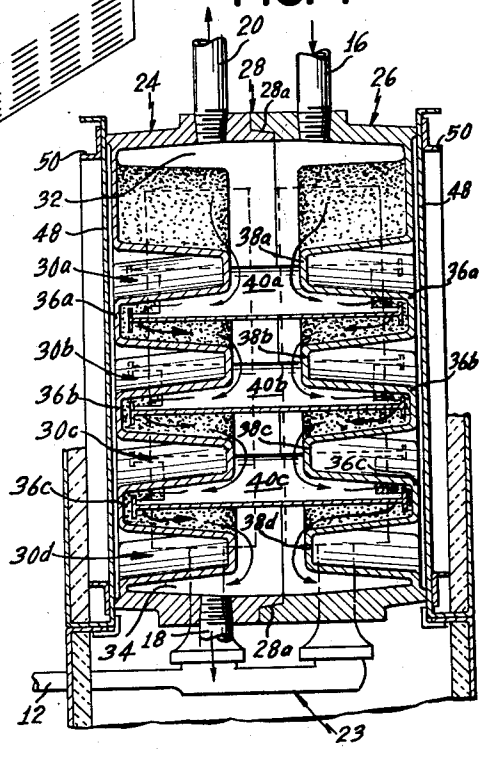


FIG. 4



INVENTORS
MELVIN DUBIN
MILTON GORDON
BENJAMIN RONN
IRVING TURINSKY

BY Paul S. Martin
ATTORNEY

March 30, 1965 M. DUBIN ETAL 3,175,540

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FIG. 5

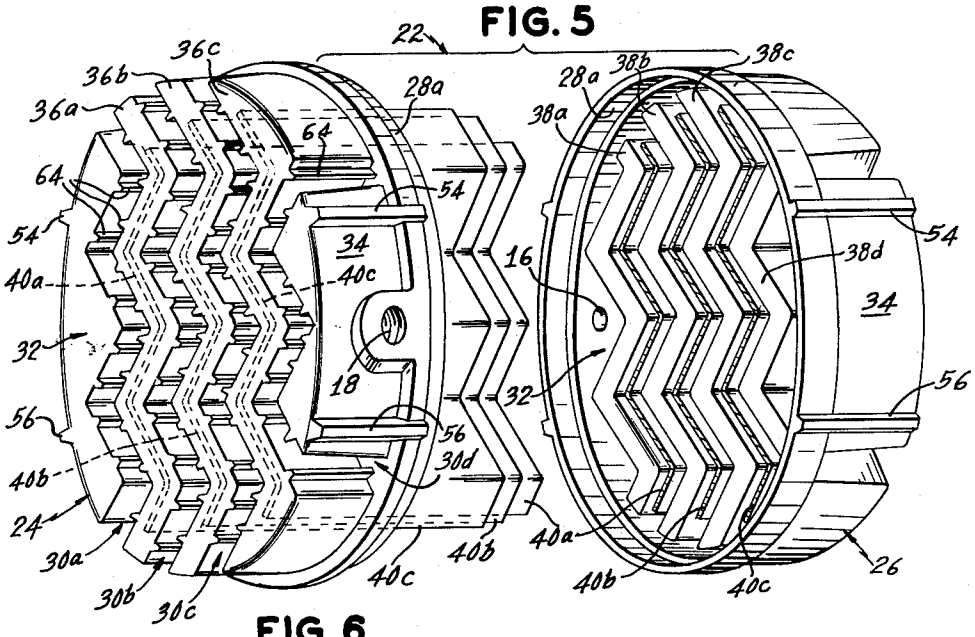


FIG. 6

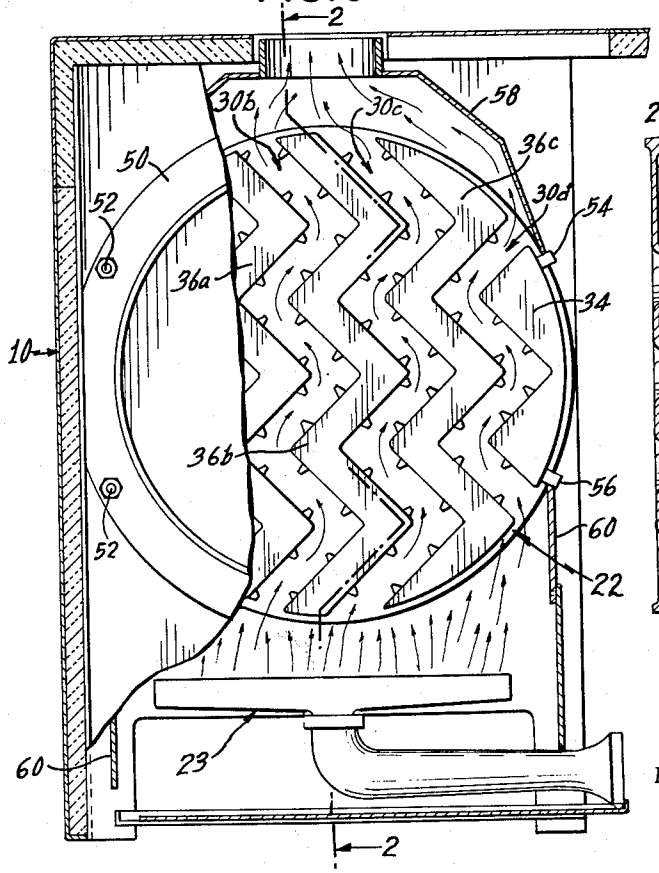
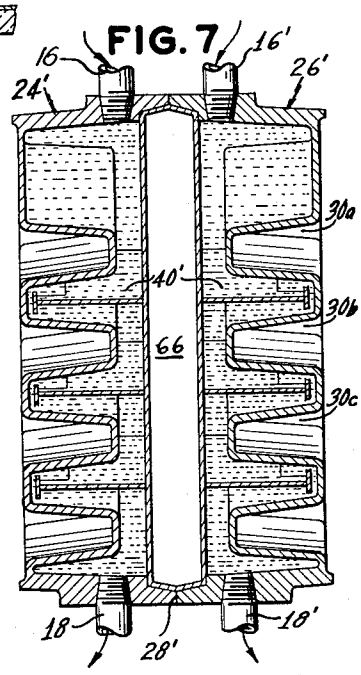


FIG. 7



INVENTORS
MELVIN DUBIN
MILTON GORDON
BENJAMIN RONN
IRVING TURINSKY

BY Paul S. Martin

ATTORNEY

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HOT WATER BOILER

Melvin Dubin, New York, and Milton Gordon, Levittown, N.Y., Benjamin Ronn, Palisades Park, N.J., and Isidore Turinsky, North Babylon, N.Y., assignors to Slant/Fin Radiator Corporation, Richmond Hill, N.Y., a corporation of New York

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7 Claims. (Cl. 122—230)

The present invention relates to boilers, particularly intended for central heating in circulating hot-water systems but having additional applications.

From the point of view of fuel economy, it is desirable that a furnace should have a boiler that effectively extracts all the heat available in the combustion gases. Carried to a limit, this could lead to immense boilers of elaborate construction. However, the boiler installation should conserve space and therefore a boiler of minimum size is desirable, consistent with efficient heat extraction as evidenced by low temperature of the discharged flue-gas, and consistent with the rated heat-extraction capacity, that is, the amount of heat per hour that can be delivered to the heating system. Minimum cost is also desirable and this, in turn, is related both to the amount of material required and to the character of the manufacturing operations required by the form of the boiler.

An object of this invention resides in the provision of a novel form of boiler that combines high efficiency with compactness, for given rated capacity. A further and important object of the invention resides in the provision of an efficient and compact boiler that is of a novel configuration providing extensive heat-exchange wall area from the combustion-gas passages to the water space, without resort to shapes or designs which would necessitate costly or exacting manufacturing methods. With particular concern for circulating hot-water heating systems, an object of the invention resides in provision of a novel form of boiler and combines the foregoing features with provision of an extended length of path of the water through the heat-exchange unit.

Hot water boilers for heating systems are generally made of cast-iron; and in order to provide extensive heat-exchange surfaces, elaborate shapes have been devised involving cavities that can be fashioned only by resort to cores in the casting process. Such a design has the effect of increasing the cost of the castings, and of allowing undue wall thicknesses so as to take into account the limitations of the manufacturing methods, notably the variations in positioning of the casting molds and cores. Excess wall thickness increases both the cost and the weight of the cast-iron used, and it also increases the wall thickness through which the heat must travel from the combustion-gas passages to the water. It is a feature of the novel heat-exchange unit provided by the present invention that a minimum of wall thickness can be attained without resort to special casting methods.

The foregoing and other objects of the invention are achieved in the illustrative embodiment and a modification that are described in detail below and are shown in the accompanying drawings. The preferred embodiment shown utilizes a pair of cast walls that incorporate relatively numerous passages of large surface area exposed to the hot combustion-gases and correspondingly numerous water spaces for extracting the heat. Casting cores are not needed in making the walls, which are sealed to each other. Despite the extensive heat-exchange area provided by formations in the walls, the two walls are joined to each other only at their periphery. The joint is especially easily made and reliable in service when it is in the form of a circle. The walls have tapered

complementary circular sealing rims in the embodiment described below. Such rims may be cast to a high order of precision without inordinate expense, and a circular tapered rim can be readily machined for ideal complementary fit, even to the extent of producing a water-tight seal without resort to sealing compounds.

The illustrative embodiment of the invention includes elongated zig-zag combustion-gas passages that alternate, horizontally, with elongated vertical zig-zag water spaces; and by proper arrangement of the water inlet and water outlet sections of the boiler and interconnection of the various water spaces, remarkably efficient and effective boiler performance is attained. For directing the flow of water through the heat-exchange unit, reliance is placed not only on the formations in the cast-iron walls of the heat-exchange unit, but in addition there is provided a series of water-space dividers that have ears by which the dividers are resiliently centered in the respective water spaces. The dividers are simply deposited in the respective water spaces, before the two walls are assembled together, and they retain their intended positions without resort to special fastening means and without resort to special mounting or sealing devices for the dividers.

The nature of the invention, and its further objects, novel features and advantages will be more fully apparent from the following detailed description in which reference is made to the accompanying drawings which form part of the present disclosure.

In the drawings:

FIG. 1 is the perspective of a hot water boiler;

FIG. 2 is a vertical section through the boiler of FIG. 1, as viewed from the line **2**—**2** in FIG. 6;

FIG. 3 is an enlarged fragmentary perspective view of a component in FIG. 2;

FIG. 4 is a horizontal cross-sectional view at the plane **4**—**4** of FIG. 2;

FIG. 5 is an exploded perspective, partly in cross-section, of certain components in FIGS. 2, 3 and 4;

FIG. 6 is a vertical cross-section of the boiler in FIGS. 1, 2 and 4, as viewed generally from the line **6**—**6** in FIG. 2; and

FIG. 7 is a horizontal cross-section of a modification, viewed corresponding to FIG. 4.

FIG. 1 shows the exterior of a hot-water boiler of a form that is suitable and intended for central heating of a home by circulating hot water, as an illustrative application of various features of the present invention. The sheet-metal exterior **10** completely encloses the heat-exchange unit and a gas burner, the walls of sheet-metal enclosure **10** being suitably insulated internally, as by rock-wool. Combustion gas may be supplied at gas-pipe **12**, and the flue gas emerges via chimney pipe **14**. Water returns from the heating system and enters the boiler at inlet pipe **16**. Heated water leaves the heat-exchange unit for recirculation via outlet pipe **18**. Another pipe **20** is shown, suitable for a temperature gage, a pressure gage, a pressure-relief valve, and any combination of these devices and others in conventional heating installations.

In FIGS. 2, 4 and 6, the boiler **22** is shown, certain important components being shown in FIG. 5. Below the heat-exchange unit is a gas burner **23**, divided into two sections as shown in FIGS. 2 and 4. Heat-exchange unit **22** includes two one-piece seamless walls **24** and **26** of cast-iron that are joined together by a circular seal **28** formed by complementary circular rims integral with walls **24** and **26**, with an appropriately tapered portion **28***a*. Walls **24** and **26** together form a generally cylindrical or barrel-shaped unit with a horizontal axis.

In FIGS. 4, 5 and 6, wall **24** is seen to include forma-

tions providing four vertical zig-zag passages **30***a*, **30***b*, **30***c* and **30***d* for the burning of hot combustion gases, or flue gases. At the horizontal extremes, diametrically, at the left and right of walls **24** and **26** as shown in FIG. 5, are water-containing sections **32** and **34** at the inlet and the outlet portions of the heat-exchange unit. These may be considered to be inlet and outlet water manifolds, distributing the water to different devices at the inlet and collecting water from different levels at the outlet side of the heat-exchange unit.

The formations in wall **24** between combustion-gas passages **30***a*, **30***b*, **30***c* and **30***d*, namely formations **36***a*, **36***b* and **36***c*, constitute vertical zig-zag water spaces. Referring to FIG. 4, formations **36***a*, **36***b* and **36***c* are shown in horizontal cross-section, and appear as loops that are directed outward relative to the internal water space. In this same horizontal cross-section, loops **38***a*, **38***b*, **38***c* and **38***d* are directed inward, relative to the water-containing space within walls **24** and **26**.

The two walls **24** and **26** are essentially mirror-images of each other, disregarding such details as the complementary formations that form circular seal **28**. Accordingly, walls **24** and **26** have aligned inwardly directed loops **38***a*, **38***b*, **38***c* and **38***d*, and correspondingly these walls **24** and **26** have aligned outwardly directed loops **36***a*, **36***b* and **36***c*.

Within loops **36***a*, **36***b* and **36***c* of both walls **24** and **26** are three vertical zig-zag dividers **40***a*, **40***b* and **40***c* of sheet-metal, preferably stainless steel. Each of these sheet-metal members **40** has a series of cut-outs, with resulting edges **42** and legs **44**, and each leg has oppositely directed ears **46**. The respective dividers **40** are centered in the corresponding vertical zig-zag water passages of formations **36***a*, **36***b* and **36***c* by virtue of the bent ears **46**; and legs **44** insure substantial spacing between the edges **42** of the dividers and the extremities of the outward directed loops **36***a*, **36***b* and **36***c*. Legs **44** and ears **46** provide yielding or resilient locating supports for the dividers. Before the two walls are assembled, the dividers are dropped into place in one wall. After the walls are assembled, ears **46** engage the converging surfaces of the outward loops to hold the dividers in position resiliently after the two walls are assembled.

A pair of vertical end plates **48** form lateral walls for the combustion-gas passages **30***a*, **30***b*, **30***c* and **30***d*. Flanking these end plates and aligned with the peripheral edges of walls **24** and **26** are clamping rings **50**. Tie rods **52** (threaded at their ends and provided with nuts) hold rings **50**, vertical plates **48**, and boiler-walls **24** and **26** in assembly as illustrated. Ribs **54** provide abutment ledges for a hood **58** that guides the flue gases from these vertical zig-zag combustion-gas passages for delivery to the flue-pipe **14**, and ribs **56** provide abutment ledges for lateral plates **60** which form a bottom fire chamber and direct the hot gases from burners **23** to the vertical zig-zag passages. Plates **60** and hood **58** extend horizontally all the way from one plate **48** to the other. These plates **48** extend to the floor and provide vertical support for the heat-exchange unit. However, plates **48** are exposed to the hot combustion gases and, both for efficient operation and for insuring a cool exterior for enclosure **10**, an appropriate amount of heat insulation such as rock wool **62** lines the internal surface of sheet-metal enclosure **10** opposite plates **48**, and elsewhere.

In operation, burning gas rises from burners **23** and travels upward via two groups of zig-zag passages **30***a*, **30***b*, **30***c* and **30***d* at opposite sides of the water-containing space within walls **24** and **26**. Ribs **64** are formed on the opposite surfaces of each of these flue-gas passages, and serve to improve heat extraction by increasing the surface of the metal wall that is exposed to the hot gases and by creating turbulence inducing the rising combustion gases to "work" intimately against the heat-transfer surfaces.

Water enters section **32** of the boiler from inlet line **16**, ordinarily the return line of a circultaing hot-water heating system. Section **32** is of substantial vertical extent (note particularly FIG. 5) and acts as an inlet manifold to spread the inlet water up and down to various levels before the water starts to cross through the boiler to the outlet manifold section **34** and outlet line **18**. Between sections **32** and **34**, the water is caused to follow horizontal zig-zag paths, as represented by the curved arrows in FIG. 4. The relationship between the combustion-gas passages and the water flow as described results in remarkably effective and efficient extraction of heat from the combustion gas and transferred to the hot water system. The temperature of the discharged flue gas is but little higher than that of the water at the oulet line **18**. In a pracical example of such a boiler, a heat-exchange unit having walls **24** and **26** approximately 20 inches in outside diameter by 13 inches in axial length has been shown in tests to yield an output of 80,000 B.t.u. per hour at 80% efficiency. Accordingly, the device shown is both compact and highly efficient, and is well suited to use in central heating systems.

The heat-exchange unit is of a construction that lends itself readily to low-cost manufacture. As seen in FIG. 4 particularly, each of the walls **24** and **26** has surfaces everywhere that have a minimum casting draft-angle so as to be well suited to simple casting methods without resort to costly special cores or the like. This is true of the inside and outside surfaces of both walls, and is true even of ribs **64**. Nevertheless, and particularly in view of the remarkably intimate heat-transfer relationship between the vertical zig-zag gas passages and the horizontal zig-zag water passages, no more than a single simple circular water-seal is involved in joining the two walls **24** and **26** together. Tapered surfaces **28***a* may have a machined finish, which is particularly easy to provide where the seal is circular. It has been found practical to assemble walls **24** and **26** together without requiring a sealing compound. Even where sealing compound is desired, the water seal involved in the illustrated boiler is extremely simple and of limited extent. Further, because of the fact that the heat-exchange unit is adapted to elemental casting methods, it has proved feasible to utilize relatively thin-wall design, thereby to reduce weight and improve heat-transfer efficiency.

A variation is shown in FIG. 7 that utilizes modified walls **24'** and **26'** of the same general shape as that in FIGS. 2, 4, 5 and 6, with a modified seal **28'** and modified divider plates **40'**. The configuration in FIG. 7 is significant in that it incorporates a hot water heating tank **66**. The apparatus in FIG. 7 is thus adapted to serve not only in a circulating hot-water heating system, but also to provide domestic hot water. Separate inlet and outlet connections are provided for the two water spaces at the opposite sides of tank **66**. It will be understood, of course, that unit **66** has appropriate cold-water inlet and hot-water outlet lines (not shown). It will also be understood that the boiler of FIGS. 2, 4, 5 and 6 may be equipped with a conventional tankless coil for providing a supply of domestic hot water. Because unit **66** as shown forms a complete barrier across the water-container, two water paths exist, and two sets of pipes **16**, **16'** at the inlet and **18**, **18'** at the outlet are provided.

Where greatly increased capacity is desired, the units illustrated in the drawings may not only be increased in size for greater heat-exchange surface area, but additional boilers **22** may be assembled in axial alignment. In that event, a flue-gas passage **30** of one unit would be aligned with a like flue-gas passage **30** of the next axially aligned heat-exchange unit; and consequently, no intervening plate **48** would be used at such confronting flue-gas passages except, possibly, for providing support.

It will be apparent that further modifications in detail and varied application of the novel features of the invention represented in the illustrative embodiment will

occur to those skilled in the art, in light of the foregoing disclosure. Consequently, the invention should be broadly construed in accordance with its full spirit and scope.

What is claimed is:

1. A hot-water boiler, including a pair of confronting walls having aligned sealing rims, said walls together defining a water-containing space and having water-inlet and water-outlet connections, each of said walls having inward and outward extending corrugations therein providing multiple outside vertically continuous zig-zag flue-gas spaces alternating horizontally with multiple inside vertically continuous zig-zag water spaces, each said zig-zag water space being approximately equal to each said zig-zag flue gas space when viewed in transverse cross-section, the corrugations of said pair of walls having a combined depth when measured along a horizontal line from one of said walls to the other that is substantially greater than half of the maximum horizontal extent of the water-containing space between said walls when measured along said line, said outward extending corrugations of each wall being coplanar, and means engaging said coplanar formations for laterally closing off said flue gas spaces.

2. A hot-water boiler, including a pair of confronting walls, said walls together defining a water-containing space and having water-inlet and water-outlet connections, each of said walls having inward and outward extending formations therein providing multiple outside vertically continuous zig-zag flue-gas spaces alternating horizontally with multiple inside vertically continuous zig-zag water spaces, said outward extending formations of each wall being coplanar, means laterally engaging said outward formations for laterally closing off said flue-gas spaces, the transverse cross-section of each said flue-gas space being at least approximately equal to that of each said zig-zag water space, and the formations of said pair of walls having a combined extent when measured along a horizontal line from one of said walls to the other that is substantially greater than half of the maximum horizontal extent of the water-containing space between said walls when measured along said line, and vertical zig-zag sheet-metal dividers in a plurality of said vertical zig-zag spaces, said walls and said dividers forming horizontal zig-zag spaces interconnecting said divided vertical zig-zag water spaces.

3. A hot-water boiler, including a pair of confronting walls having mating tapered circular sealing rims, said walls together defining a water-containing space and having water-inlet and water-outlet connections, each of said walls having inward and outward projecting formations therein providing multiple outside vertically continuous zig-zag flue-gas spaces alternating horizontally with multiple inside vertically continuous zig-zag water spaces, each said zig-zag water space being approximately equal to each said zig-zag flue-gas space when viewed in transverse cross-section, the formations of said pair of walls having a combined extent when measured along a horizontal line from one of said walls to the other that is substantially greater than half of the maximum horizontal extent of the water-containing space between said walls when measured along said line, said inward and outward projecting formations of each of said walls being disposed at opposite sides of a respective vertical plane.

4. A hot-water boiler, including a pair of confronting walls having aligned sealing rims, said walls together defining a water-containing space and having water-inlet and water-outlet connections, each of said walls having outward and inward formations therein disposed alternately at opposite sides of a vertical plane providing multiple outside vertically continuous zig-zag flue-gas spaces alternating horizontally with multiple inside vertically continuous zig-zag water spaces, said zig-zag water spaces and said zig-zag flue-gas spaces being substantially equal when viewed in transverse cross-section, said formations of said pair of walls being greater in extent when measured along a horizontal line from one of said walls to the other than half of the extent of said water-containing space between said walls when measured along that line, each said wall having sloping surfaces providing a forming draft-angle throughout in opposite directions relative to said sealing rims.

5. A hot-water boiler, including a pair of confronting walls having aligned sealing rims, said walls together defining a water-containing space and having water-inlet and water-outlet connections, each of said walls having formations therein providing multiple outside vertically continuous zig-zag flue-gas spaces alternating horizontally with multiple inside vertically continuous zig-zag water spaces, said zig-zag water spaces and said zig-zag flue-gas spaces being approximately equal when viewed in transverse cross-section, the formations of said pair of walls having a combined extent when measured along a horizontal line from one of said walls to the other that is substantially greater than half of the maximum horizontal extent of the water-containing space between said walls when measured along said line, said formations of each of said walls extending outward to a respective common plane, and a plate against the outward extending formations of each of said walls, respectively, laterally closing off said flue-gas spaces.

6. A hot-water boiler, including a unitary seamless heat-exchange wall having formations affording a series of vertically continuous flue-gas spaces separated by vertically continuous zig-zag water-containing spaces whose cross-section approximates that of the flue-gas spaces, the horizontal cross-section through said formations presenting a series of connected loops extending alternately outward and inward relative to the water-containing space and the outward extending formations being coplanar, the flue-gas spaces being constituted by the spaces between said outward loops, means confronting the successive inward loops but spaced therefrom by less than the inward-to-outward extreme portions of said formations, and said last-named means having a tapered circular rim sealed to a complementary peripheral edge of said heat-exchange wall, said last-named means providing a confronting wall for said heat-exchange wall, and means laterally engaging said coplanar outward extending formations for laterally closing off said flue-gas spaces.

7. A hot-water boiler, including a generally barrel-shaped heat-exchange unit disposed with its axis extending horizontally and having two confronting individually seamless heat-exchange walls having complementary tapered circular rims and sealed to each other only at said rims, said walls together defining a water-containing space and having water-inlet and water-outlet connections, each of said walls having inward and outward extending formations therein providing multiple outside vertically continuous zig-zag flue-gas spaces alternating horizontally with multiple inside vertically continuous zig-zag water spaces, said zig-zag water spaces and said zig-zag flue-gas spaces being approximately equal when viewed in transverse cross-section, said formations of said pair of walls having a combined extent when measured along a line extending horizontally from one of said walls to the other that is substantially greater than half the horizontal extent of said water-containing space between said walls when measured along said line, said outward extending formations of said walls extending to a pair of vertical planes, respectively, and a pair of plates laterally closing off said flue-gas spaces and engaging said outward extending formations, respectively, said plates being secured to said walls and extending below said walls and constituting supporting means for said walls.

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PERCY L. PATRICK, *Primary Examiner.*

FREDERICK L. MATTESON, JR., *Examiner.*