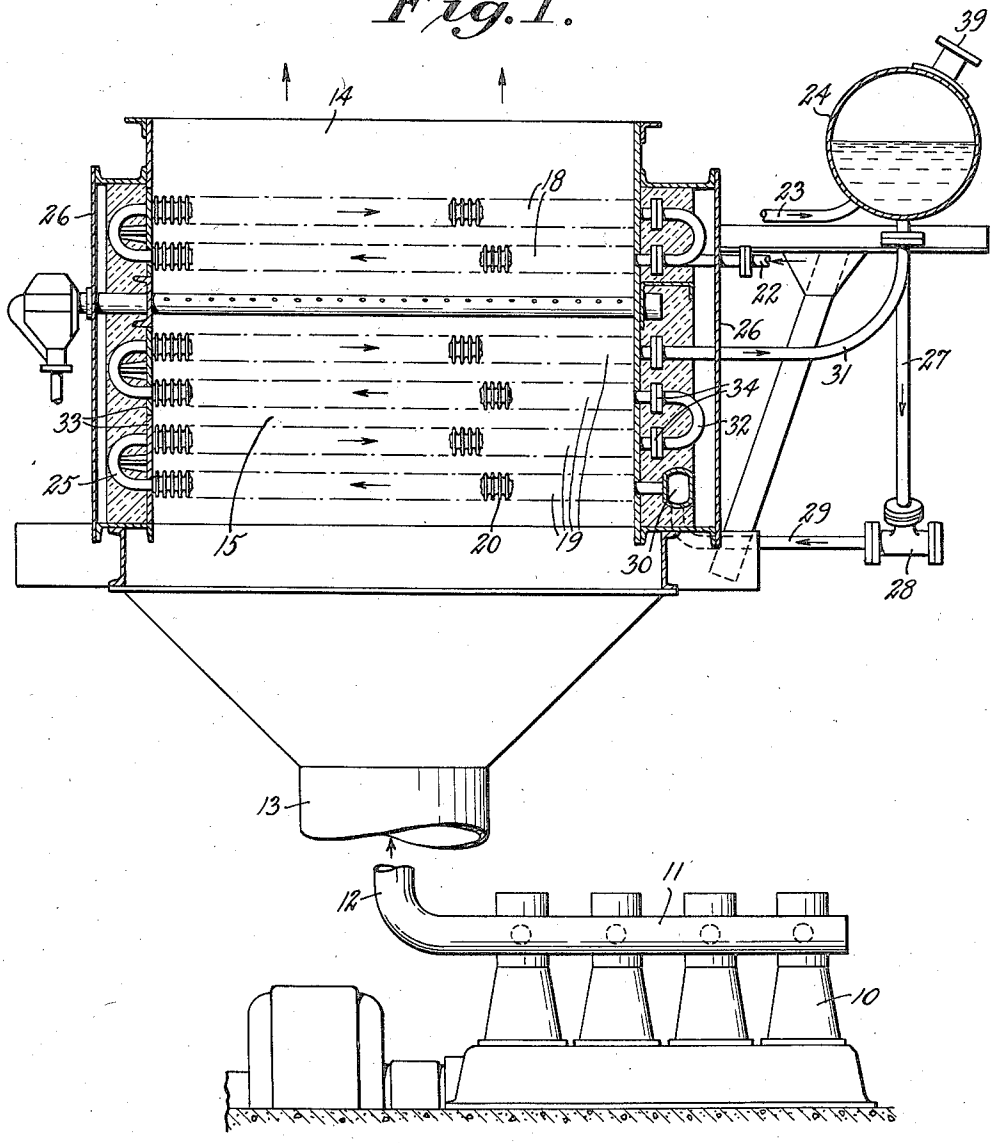
Feb. 18, 1936. W. F. KEENAN, JR 2,031,423

POWER PLANT

Original Filed March 15, 1929 2 Sheets-Sheet 1

Fig. 1.



INVENTOR,
WALTER F. KEENAN, JR.
BY
William G. McKnight
ATTORNEY.

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Original Filed March 15, 1929 2 Sheets-Sheet 2

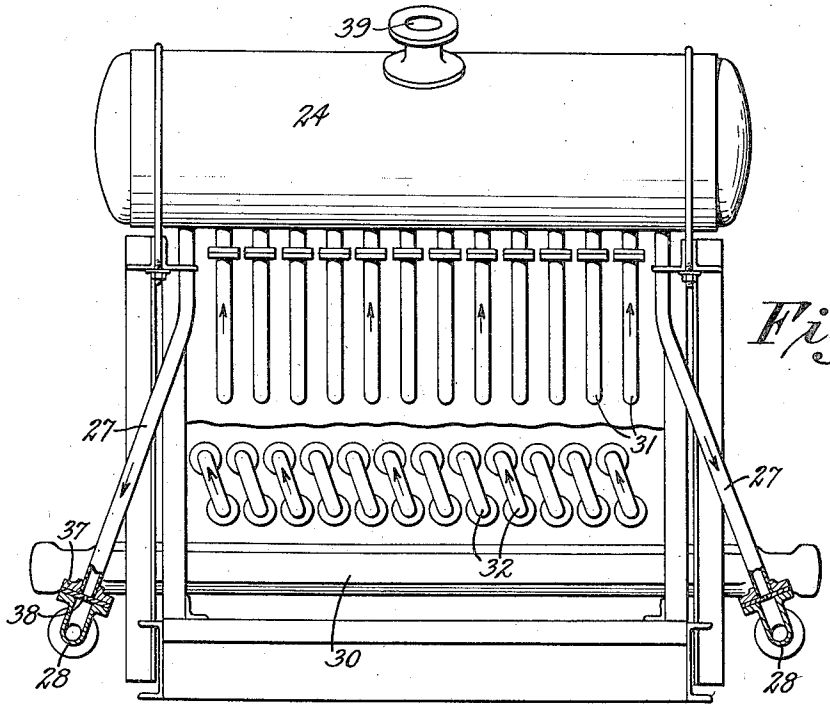


Fig. 2.

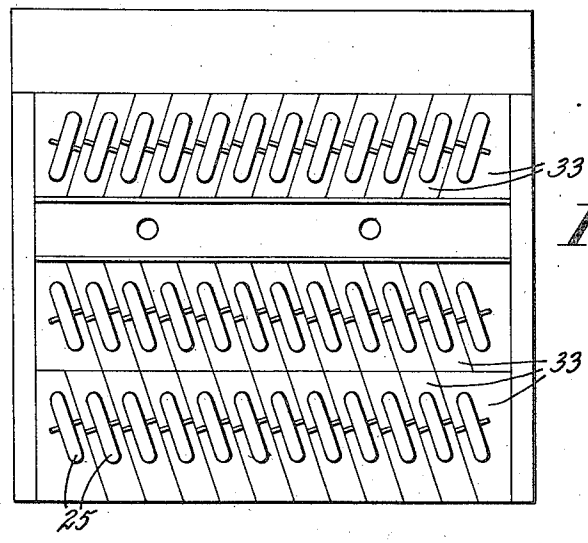


Fig. 3.

INVENTOR,
WALTER F. KEENAN, JR.

BY
William G. McClung Jr.
ATTORNEY.

Patented Feb. 18, 1936

2,031,423

UNITED STATES PATENT OFFICE

2,031,423

POWER PLANT

Walter F. Keenan, Jr., Pelham Manor, N. Y., assignor to Foster Wheeler Corporation, New York, N. Y., a corporation of New York

Original application March 15, 1929, Serial No. 347,434. Divided and this application October 12, 1934, Serial No. 748,143

8 Claims. (Cl. 122—355)

This application is a division of application Serial No. 347,434, filed March 15, 1929, by me jointly with James Slack Malseed and John Thomas Welsh.

My invention provides a novel boiler circulatory system which utilizes horizontally disposed tubes for the heating elements. The invention is particularly well adapted to the recovery of waste heat such as contained in the exhaust gases of internal combustion engines and to muffle the exhaust of such engines, but the invention is not limited thereto.

Prior types of steam generators which operate by natural or thermo-syphon circulation, have their heating or steam generating elements disposed at various convenient angles ranging between the vertical and an inclined horizontal. Such disposition of the heating elements has been thought necessary heretofore to cause the steam when generated in the heating elements to flow only in the direction desired for the circulation through the generator. The inclination of the tubes from the horizontal causes the steam always to move toward the highest point in each heating element in the path of lesser resistance and thereby provide a definite circulation through the boiler. However, when horizontally disposed heating elements are utilized without means for forcing circulation in the desired direction, the steam upon generation in the heating elements will tend to flow in both longitudinal directions of the elements and no circulation will ensue.

My invention overcomes this difficulty and provides a boiler employing horizontally disposed heating elements, with a positive natural circulation.

The nature of the invention will be understood from the following description taken in connection with the accompanying drawings, forming a part hereof, and in which:

Fig. 1 is a vertical sectional view of a boiler embodying the invention and arranged to recover the heat from the exhaust gases of an internal combustion engine;

Fig. 2 is an elevational view of the right hand end of the boiler shown in Fig. 1; and

Fig. 3 is an elevational view of the left hand end of the boiler shown in Fig. 1 with the insulation and its casing removed.

Referring to the drawings, reference character 10 designates an internal combustion engine of any type, a Diesel engine for example, having an exhaust manifold 11 which receives exhaust gases from the engine and delivers them to an exhaust pipe 12 from which they are discharged into the inlet 13 of the boiler. After flowing over the heating elements of the boiler the exhaust gases flow out of the boiler outlet 14 and may be conducted to a flue or stack.

The boiler heating chamber, designated 15 is defined by vertically disposed walls of substantial construction to withstand the relatively severe pulsations of pressure of the exhaust gases.

The heating elements of the boiler are horizontally disposed in the heating chamber 15. In the embodiment shown, two rows of economizer tubes 18 and four rows of boiler tubes 19 are employed, with the economizer tubes disposed at the upper part of the heating chamber above the boiler tubes. The tubes 18 and 19 are preferably straight steel pipes encased in cast iron members 20 which provide extended surfaces in the form of a plurality of outwardly tapering fins or gills. The members 20 may be applied to the tubes in a number of ways but preferably they are separate rings or groups of rings which are shrunk onto the tubes and are fitted together with dovetail joints so as to completely surround and encase the tubes.

The tubes of each horizontal row or bank are preferably spaced relatively close together so that the fins 20 almost contact each other. The rows of tubes are spaced farther apart than the spacing of the tubes in each row, to thereby provide distinct restrictions in the path of flow of the gases passing through the heating chamber so that the gases are successively restricted and expanded. The tubes of adjacent rows are also staggered to break up the gas flow and cause the gases to flow in a tortuous path through the heating chamber.

Water is supplied to the boiler through conduit 22 to the economizer tubes 18 and after passing therethrough flows into conduit 23 into the lower part of a steam and water drum 24 disposed outside the heating chamber and, as shown, transversely to the heating elements. Economizer tubes 18 are connected serially by U-bends disposed outside the heating chamber and are encased in insulation within casing 26.

Water flows from drum 24 down through two side connections 27, T connections 28 and connections 29 into manifold 30 extending the width of the boiler at the height of the lowest row of tubes. T connections 28 are arranged below manifold 30 and connections 29 are bent upwardly to connect to the manifold. From manifold 30, the water flows in parallel to all the individual tubes of the lowest row, thence in parallel successively through individual tubes of the other rows and through connections 31 into the bottom of the steam and water drum. U-

bends outside the walls in casings **26** connect vertically disposed boiler tubes in series. As there are twelve tubes to a row, and four rows of boiler tubes in the embodiment shown, there are twelve groups of four tubes each connected in series between the manifold and the steam and water drum.

The tubes are made of U-bend units, each unit having a plate **33** arranged thereon at the bent end. Plates **33** are of various shapes as shown in Fig. 3 and together constitute one of the walls of the heating chamber **15**. The ends of the tubes opposite the bends are expanded into the heating chamber wall and have flanges **34** at their ends outside the wall for connection to U-bends **32**. Plates **33** are held by the tubes. Ribs **34** on plates **33** bear against the tube bends **25** and serve to determine the position of the plates to build up the wall member. Tightness at this side of the chamber is obtained by tightness of casing **26** enclosing the tube bends.

While it is preferable that all the parts coming in contact with the exhaust gases be of cast iron, it is more practical to make the walls of steel in order to facilitate manufacture. The steel plate for the walls can be made so heavy, for example over an inch thick, as to permit corrosion thereof without injury to the boiler.

It will be seen that by the arrangement above described it is in reality easy to maintain gas tightness of the boiler heating chamber. This is facilitated by the horizontal arrangement of tubes and by the arrangement of vertical series connection. In an ordinary boiler fired by coal or the like, the combustion chamber and flue gas passages are under vacuum and if there is a leakage it is into this space and is objectionable only because of its adverse effect on efficiency but any such leakage would not create a nuisance or affect the atmosphere in any way around the boiler. However, where the gas pressure is at times above atmospheric, gas leaks cannot be permitted. In my construction each side of the heating chamber is made tight as above explained and the corners are tightly secured together.

Between flange **37** at the bottom of each connection **27** and T connection is an orifice plate **38** having an orifice in the same constituting the smallest cross-section of water flow in the boiler. This restricts flow of water to the boiler so as to supply water only slightly in excess of the amount of steam generated and prevents back flow through the boiler elements. Furthermore by having connection **29** bent upwardly toward manifold **30**, reverse flow of steam is prevented because the steam would have to travel downwardly from the boiler elements to pass up the connections **27**.

I prefer to connect the steam connections **31** to the steam and water drum at the bottom to provide a slight down flow of water on the surface of connections **31** against the upflow of the steam generated which augments the normal supply to the generating tubes through connections **27** and because the steam flow bubbling up through the water in the steam and water drum maintains this water at steaming temperature so that when it is fed to the lower tubes it is ready to flash into steam the instant any heat is added and no addition of sensible heat to the water in the tubes is necessary. This stabilizes the circulation through the boiler.

The economizer is placed at the exhaust gas outlet in order to reduce the temperature of the gases to a minimum and to act as a spark arrester by materially cooling down the gases. Diesel and other engines intermittently discharge sparks which settle on canvas and other flammable materials. By passing them over cold economizer tubes these sparks are cooled to the point where they will not set fire to material on which they light.

The economizer by producing greater average mean temperature differences and what might be described as partial counter-flow of gas and water through the muffler increases the heat absorbing capacity of the system. It will be noted that the greatest heat absorption is at the places of smallest area of gas travel whereby the heat absorption aids in the muffling effect.

Steam is taken off from the drum through connection **39** and may be put to any suitable use. When my invention is applied to ships, the steam may be used to drive auxiliaries and for heating, cooking and other miscellaneous purposes. In the event it is found that additional muffling effect is desired over that produced by the boiler disclosed, a known type of muffler not embodying a boiler may be added. Such muffler will be of smaller size than if no boiler were used by an amount determined by the effectiveness of the boiler as a muffler.

With the boiler circulatory system of my invention, stability of circulation is provided although horizontally disposed heating tubes are utilized and no pump or other device is employed to provide forced circulation.

Since changes may be made in the form, location and arrangement of the various parts of the boiler disclosed herein, without departing from the principle of the invention, it is understood that no intention is entertained to limit the invention except by the scope of the appended claims.

What I claim is:

1. A boiler comprising walls forming a heating zone, a plurality of horizontally disposed tubes in said heating zone arranged one above the other, connections between said tubes outside said heating zone for flow of water and steam from each tube to the next higher tube, a steam and water drum outside said heating zone and disposed above the highest of said tubes, a connection outside said heating zone between the highest of said tubes and the bottom part of said steam and water drum, a down-comer connection outside said heating zone between the water space of said steam and water drum and the lowest of said tubes, a fixed orifice member in said down-comer connection proportioned to supply water to said tubes only slightly in excess of the amount of steam generated for stabilizing circulation at high ratings, and said down-comer connection extending below the lowest of said tubes and having an upwardly extending unheated portion for preventing reversal of circulation at low ratings.

2. A boiler comprising walls forming a heating zone, a plurality of horizontally disposed tubes in said heating zone arranged one above the other, connections between said tubes outside said heating zone for flow of water and steam from each tube to the next higher tube, a steam and water drum outside said heating zone, a connection outside said heating zone between the highest of said tubes and said steam and water drum, a down-comer connection outside said heating zone between the water space of said steam and water drum and the lowest of said tubes, a fixed orifice member in said down-comer connection proportioned to supply water to said tubes only slightly

in excess of the amount of steam generated for stabilizing circulation at high ratings, and said down-comer connection extending below the lowest of said tubes and having an upwardly extending unheated portion for preventing reversal of circulation at low ratings.

3. A boiler comprising walls forming a heating zone, a plurality of horizontally disposed tubes in said heating zone arranged one above the other, connections between said tubes outside said heating zone for flow of water and steam from each tube to the next higher tube, a steam and water drum outside said heating zone and disposed above the highest of said tubes, a connection outside said heating zone between the highest of said tubes and said steam and water drum, a down-comer connection outside said heating zone between the water space of said steam and water drum and the lowest of said tubes, a fixed orifice member in said down-comer connection proportioned to supply water to said tubes only slightly in excess of the amount of steam generated for stabilizing circulation at high ratings, and said down-comer connection extending below the lowest of said tubes and having an upwardly extending portion for preventing reversal of circulation at low ratings.

4. A boiler comprising walls forming a heating zone, a plurality of horizontally disposed tubes in said heating zone arranged one above the other, connections between said tubes for flow of water and steam from each tube to the next higher tube, a steam and water drum, a connection between the highest of said tubes and said steam and water drum, a down-comer connection between said steam and water drum and the lowest of said tubes, an orifice member in said down-comer connection proportioned to supply water to said tubes only slightly in excess of the amount of steam generated, and said down-comer connection extending below the lowest of said tubes and having an upwardly extending portion, said orifice member and said upwardly extending portion of said down-comer connection serving to control circulation.

5. A boiler comprising a heating chamber, a plurality of horizontally disposed tubes in the heating chamber arranged and connected to provide vertical series flow of steam and water therethrough, a steam and water drum, a connection between the uppermost of said tubes and the steam and water drum, and a down-comer connection between the steam and water drum and the lowermost of said tubes, said drum being disposed so that the normal water level therein is above the tubes, said downcomer connection being arranged to supply water to said tubes only slightly in excess of the amount of steam generated and having a portion disposed below the lowermost of said tubes and an upwardly extending portion outside said chamber connecting with the lowermost of said tubes to provide stable circulation through the boiler.

6. A boiler comprising a heating chamber, a plurality of horizontally disposed tubes in the heating chamber arranged and connected to provide vertical series flow of steam and water therethrough, a steam and water drum disposed so that the normal water level therein is above said tubes, a connection between the uppermost of said tubes and the steam and water drum, a down-comer connection outside said chamber between the steam and water drum below the normal water level therein and the lowermost of said tubes, said down-comer connection being arranged to supply water to said tubes only slightly in excess of the amount of steam generated in said tubes, said down-comer connection having a portion disposed below the lowermost of said tubes and having an upwardly extending portion outside said chamber connecting with the lowermost of said tubes.

7. A boiler comprising a heating chamber, a plurality of horizontally disposed tubes in the heating chamber arranged and connected to provide vertical series flow of steam and water therethrough, a steam and water drum disposed so that the normal water level therein is above said tubes, a connection between the uppermost of said tubes and the steam and water drum below the normal water level therein, a downcomer connection outside said chamber between the steam and water drum below the normal water level therein and the lowermost of said tubes, said down-comer connection being arranged to supply water to said tubes only slightly in excess of the amount of steam generated, said down-comer connection having a portion disposed below the lowermost of said tubes and having an upwardly extending portion outside said chamber connecting with the lowermost of said tubes.

8. A boiler comprising a heating chamber, a plurality of horizontally disposed tubes in the heating chamber arranged and connected to provide vertical series flow of steam and water therethrough, a steam and water drum disposed so that the normal water level therein is above said tubes, a connection between the uppermost of said tubes and the steam and water drum below the normal water level therein, a downcomer connection outside said chamber between the steam and water drum below the normal water level therein and the lowermost of said tubes, said down-comer connection having an orifice member therein proportioned to supply water to said tubes only slightly in excess of the amount of steam generated, said down-comer connection having a portion disposed below the lowermost of said tubes and having an upwardly extending portion outside said chamber connecting with the lowermost of said tubes.

WALTER F. KEENAN, JR.