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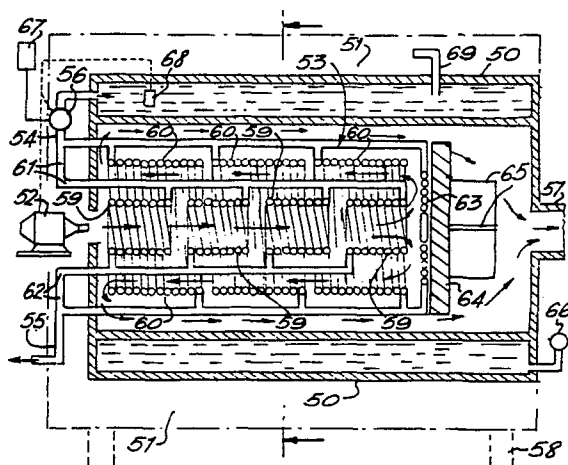
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54 **Water heating apparatus.**

57 The apparatus has a horizontal tunnel-like passage for hot combustion gases from a fuel burner (52) to a flue outlet (57). The passage is defined by several adjacent but discrete helical coils (59) each comprising from 3 to 12 turns of water conduit, such as copper tubing. A common source (54) feeds water separately to all the coils which in turn discharge heated water separately to a common outlet (55). In one embodiment, an additional outer set of coils (60), similarly connected, may create an annular space around the tunnel-like passage and an exterior water jacket (50) a second, outermost annular space. These spaces and the tunnel-like passage can be connected in various ways to impart series or parallel flow to the hot combustion gases therein. The apparatus is suitable for use in central heating systems.



Water Heating Apparatus

This invention relates to a water heating apparatus, for domestic, institutional, industrial and other purposes. It relates in particular to a water heating apparatus of the type having a passage for hot combustion gases leading from a fuel burner to a flue outlet, wherein a substantial length of the passage is defined by a heat exchanger, hereinafter referred to as a water heating apparatus of the type described.

In many examples of water heating apparatus of the type described, a water jacket defines, or partly defines, a fire box into which the flame of a burner is directed in use. The inner wall of the water jacket, which defines or partly defines the fire box, is a sheet of metal, usually cast iron, and constitutes the sole heat exchanger through which heat energy generated by the burning of fuel is communicated to the water to be heated. This arrangement suffers from several disadvantages. Thus the heat exchanger surface exposed to the flame or hot combustion gases is small, the mass of water that lies behind the heat exchanger is relatively large, heating of the water depends largely on the generation

of convection currents within said mass of water, and the latter process is hampered firstly by the low thermal conductivity of water, and secondly by the absence in most cases of forced circulation or agitation of the water. Furthermore it is not possible to heat a small amount of water for urgent requirements; the whole mass of water present must be heated to a given temperature before any water can be drawn off at that temperature.

The present invention is directed towards the amelioration of some or all of the above recited drawbacks of conventional water heating apparatus.

The invention accordingly provides a water heating apparatus of the type described, which is characterised in that the heat exchanger comprises a plurality of adjacent substantially helical coils, that each coil comprises from 3 to 12 turns of a water conduit, and that each coil is arranged to convey water separately from a source common to all the coils to an outlet common to all the coils.

A preferred water conduit is metal tubing, copper tubing being specially preferred because of its high thermal conductivity and the ease with which it may be formed into helical coils. A useful size of copper tubing is of internal diameter about 12 mm, though diameters ranging from 5 to 40 mm are within the scope of the invention.

The coils may be arranged to form a simple rectilinear tunnel with the burner located at one end and the flue outlet at the other end thereof. Or such a tunnel may be enclosed within an outer shell coaxially spaced apart therefrom, to yield a combustion gas passage which consists of a central tunnel and a space of annular cross-section therearound. In the latter case the apparatus may be arranged so that the combustion gases travel in a single direction through the central tunnel and the annular space in parallel; or it may be arranged so that the stream of gases traverses the said two spaces in succession, its direction being reversed in midstream by appropriate constructional features.

Alternatively the coils may comprise two sets, namely a first set of adjacent coils of a first diameter and a second similar set of greater diameter disposed outside the first set and spaced apart therefrom in substantially coaxial manner. Through the two spaces created by this arrangement the stream of gases may be caused to flow either in parallel or in succession, as in the previous case described. What is more, an outer shell may be provided thus creating a third (annular) space, and the stream of gases may then be caused to flow through the three spaces in succession or in parallel or in a selected combination of those modes.

A preferred embodiment of the invention is a simple series arrangement of the three spaces last referred to, in which the gas stream first passes along the central tunnel, then passes back between the two sets of coils and afterwards resumes its original direction between the outer set of coils and the outer shell before finally arriving at the flue outlet.

The outer shell, when present, may be a part of a water jacket which constitutes the common source of water above referred to. Such a jacket has two useful characteristics. Firstly it serves as a thermal insulator for minimising heat losses from the combustion gases passage. Secondly, any heat absorbed by the jacket serves to raise the water temperature therein, thereby reducing the overall energy requirement of the apparatus. An insulating jacket of conventional type may advantageously be provided to enclose the water jacket itself, thereby further reducing heat losses.

Each coil of water conduit preferably comprises from 5 to 10 turns, still more preferably from 6 to 8 turns, most preferably about 6 turns.

The apparatus of the invention may be used for heating water for a variety of purposes and on widely different scales. A useful application is for a domestic central heating system and for this purpose a preferred

embodiment comprises 6 coils of 12 mm internal diameter copper tubing disposed in the simple series arrangement of three spaces described above, with 3 coils of 8 turns each in the inner set, and 3 coils of 12 turns each in the outer set, the whole surrounded by a cylindrical water jacket externally lagged. A conventional oil burner is used, with the burner jet horizontally disposed to direct the flame axially into the central tunnel.

A water pump is incorporated, arranged to switch on and off in response to a room thermostat located in the space to be heated. The common outlet feeds hot water to a set of room heaters conventionally connected, and the heaters feed it back to the water jacket, which forms the common source above referred to. A burner thermostat is located in the water jacket, and operates to ignite the burner whenever the water temperature in the jacket falls below a predetermined working value, for example 50°C. The burner thermostat however is subordinated to the room thermostat, so as to operate the burner only while the pump is working, i.e. while there is a demand for hot water for space heating. The capacity of the pump is so selected, and the flow from the common source to the coils so adjusted (e.g. by valves) as to achieve a predetermined water temperature, for example 80°C, in the common outlet. This completes the general description of an embodiment of the invention intended for domestic central heating.

The invention will be understood in greater detail from the following description of a specific embodiment thereof, given by way of example only, with reference to the accompanying drawings, all of which are schematic sectional representations. In the drawings,

Fig. 1 is a side elevation of a domestic central heating boiler of a conventional type;
Fig. 2 is a side elevation of a domestic central heating boiler according to a first embodiment of the invention;

Fig. 3 is a side elevation of a domestic central heating boiler according to a second embodiment of the invention; and

Fig. 4 is a cross-section of the boiler of Fig. 3, taken along the line IV-IV in that figure and viewed in the direction of the associated arrows.

Referring now to Fig. 1, a conventional domestic central heating boiler comprises an oil burner 10, a fire box 11, a water jacket 13 that surrounds the fire box 11 on all sides except the front, where the burner 10 is mounted, and a plurality of fire tubes 12 leading from the fire box 11 to a flue outlet 14.

Referring to Fig. 2, a simple domestic central heating boiler of the invention comprises a cylindrical fire box 20 mounted on support structures 21, an oil burner 22, inlet and outlet pipes 23 and 24 respectively for water to be heated, a water pump 25, a heat exchanger 26 and a flue outlet 27. The fire box 20 is surrounded by an insulating jacket 28. The heat exchanger 26 comprises three discrete but adjacent substantially helical coils 29,30,31 each comprising four turns of 12 mm internal diameter copper tubing. Each coil 29,30,31 in use is fed from a respective limb of a feed manifold 32 extending from the inlet pipe 23, and discharges through a respective limb of an outlet manifold 33 which communicates with the outlet pipe 24.

The coils 29,30,31 form a continuous tunnel for the hot combustion gases, and are shown as separated merely for clarity in the drawing, being spatially un-separated in fact. Similarly the coils 29,30,31 are disposed adjacent the cylindrical shell 34 of the fire box 20 in fact, the apparent gap being necessitated for clarity in showing the connections of the manifolds 32,33. A baffle 35 of refractory material constricts the passage for the

hot combustion gases to promote maximum contact thereof with the heat exchanger before said gases reach the flue outlet 27.

Referring now to Fig. 3, a larger central heating boiler comprises a water jacket 50, an insulating jacket 51, an oil burner 52, a heat exchanger 53, inlet and outlet pipes 54 and 55 respectively for water to be heated, a water pump 56 and a flue outlet 57. The whole assembly stands on a support structure having legs 58.

The heat exchanger 53 comprises a coaxial pair of tunnels formed by a set of four inner coils 59 of eight turns each, and a set of three outer coils 60 of twelve turns each, all the coils being of copper tubing similar to that of Fig. 1. The coils in each set are adjacent, the apparent gaps between them being shown in the drawing only for clarity. The pair of tunnels is enclosed within a shell which serves as the inner wall of a water jacket 50.

Each coil 59,60 in use is fed from a respective limb of a feed manifold 61 extending from the inlet pipe 54, and discharges through a respective limb of an outlet manifold 62 which communicates with the outlet pipe 55. An additional coil 63, spiral in form, is connected between the manifolds 61 and 62 and helps to define a first U-turn in the passage for hot combustion gases, as shown by the associated arrows. Similar arrows outline the remainder of the passage, which is S-shaped in overall longitudinal section, as can be seen.

A baffle 64 of refractory material, backed by metallic guide plates 65, helps to confine the stream of gases to the required pathway. A manometer and pressure regulating equipment 66 are indicated schematically. A room thermostat 67 and a boiler thermostat 68, with circuitry enabling them to govern the operation of the pump 56 and the burner 52 respectively, complete the apparatus.

The outlet pipe 55 feeds the radiators or convectors (not shown) of a central heating system, the return flow from which re-enters the water jacket 50 via a return pipe 69.

In use, the room thermostat 67 governs the operation of the pump 56 to circulate heating water from the apparatus through the central heating system radiators; during operation of the pump the boiler thermostat 68 additionally ignites the burner 52 whenever and for as long as the water reserve in the jacket 50 is below a preset temperature such as 50°C . During normal operation with the burner off, the water temperature at the outlet pipe 55 is that of the water reserve in the jacket 50. With the burner in action, the said temperature has a different value, such as 80°C , which can be set by choice of components and adjustment of water flow and other parameters.

Referring now to Fig. 4, in which corresponding elements bear the same reference numerals as in Fig. 3, it is to be noted that the layout of the manifolds 61,62 bears a closer resemblance to actuality than in Fig. 3, having been simplified in the latter figure for clarity. The passage for hot combustion gases comprises three successive sections 70,71,72 here seen in cross-section. It is preferred that the cross-sectional areas of these three sections should be approximately equal, although this is not apparent from the drawing. This provision helps to achieve a constant speed for the stream of gases.

Some of the advantages of the invention will be appreciated from the following example descriptive of a pilot test carried out thereon.

EXAMPLE.

A test run was carried out on a conventional water heating apparatus similar to that of Fig. 1 above, during which the apparatus was fed with mains water at 12°C , at a rate of 7.5 litres per minute. The temperature of the output water was observed until it became steady, which it did at 80°C . Thus the apparatus took 20 minutes to heat 150 litres of water through $80-12 = 68^{\circ}\text{C}$.

An apparatus of the invention similar to that of Fig. 2 was constructed, having however only two coils because of the difficulty of fabricating such coils by hand. Instead of the third coil an asbestos pipe section was substituted to guide the combustion gases. The coils were separately fed with mains water at 12°C. The same burner used in the above described test run was removed from the conventional apparatus and mounted in the apparatus of the invention. With the burner in action, the rate of flow was adjusted until the output temperature became steady at 80°C, whereupon the flow rate was measured and was found to be 100 litres per minute (i.e. 50 litres from each of the two coils connected to the common outlet pipe).

This experiment, like the test run above, was continued for 20 minutes and yielded $20 \times 100 = 2000$ litres of water at 80°C. The temperature of the combustion gases exiting at the flue connection was found to be of the order of 200°C. It was therefore believed safe to assume that as many as six coils could have been used, preferably in two coaxial sets of three similar to the embodiment of Figs. 3 and 4, and a substantially uniform output water temperature of 80°C achieved with the same flow rate of 50 litres per minute through each coil. This extrapolation gives an output of $6 \times 50 = 300$ litres per minute, or 6000 litres in 20 minutes heated through a temperature span of 68°C, which is $6000/150 = 40$ times the performance of the conventional apparatus using the same conventional oil burner.

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CLAIMS:-

1. A water heating apparatus of the type having for hot combustion gases a passage leading from a fuel burner to a flue outlet, a substantial length of the passage being defined by a heat exchanger, wherein the apparatus is characterised in that the heat exchanger (26;53) comprises a plurality of adjacent substantially helical coils (29-31;59,60), that each coil comprises from 3 to 12 turns of a water conduit, and
5 that each coil is arranged to convey water separately from a source (23;54) common to all the coils, to an outlet (24,55) common to all the coils.
2. A water heating apparatus according to claim 1, wherein the coils (29-31) are arranged to form a single
15 rectilinear tunnel.
3. A water heating apparatus according to claim 2, wherein the tunnel is enclosed within a shell (34), and in that the combustion gas passage consequently consists of said tunnel and a space of annular cross-section
20 therearound.
4. A water heating apparatus according to claim 1, wherein the coils (59,60) are arranged to form a substantially coaxial pair of tunnels.
5. A water heating apparatus according to claim 4,
25 wherein the pair of tunnels is enclosed within a shell (50) and in that the combustion gas passage consequently consists of the inner tunnel (70) of the pair, a space (71) of annular cross-section between the tunnels and a similar space (72) between the pair of tunnels and the shell.
- 30 6. A water heating apparatus according to claim 3 or 5 wherein the shell partly defines a water jacket (50).

7. A water heating apparatus according to claim 6, wherein the water jacket (50) is connected to the coils, the connection serving as the common source (54) or the common outlet.
- 5 8. A water heating apparatus according to any claim above, wherein each coil comprises from 5 to 10 turns, preferably 6 to 8 turns, more preferably 6 turns.
9. A water heating apparatus according to any of claims 4 to 8, comprising an inner set of 3 coils (59) of 8
10 turns each, and an outer set of 3 coils (60) of 12 turns each, the two sets of coils being surrounded by a water jacket (50).
10. A water heating apparatus according to claim 9, further comprising an oil burner (52) with the burner jet horizontally disposed to direct the flame axially into
15 the inner tunnel (70).
11. A central heating system characterised by the inclusion of a water heating apparatus according to any claim above.
12. A central heating system according to claim 11
20 having a burner (52) and a water circulating pump (56) and adapted to achieve a predetermined water temperature, for example about 80°C, in the common outlet (55).
13. A central heating system according to claim 12 having a water jacket (50) with a burner thermostat (68) located
25 therein, the thermostat being adapted to ignite the burner (52) whenever the water temperature in the jacket falls below a predetermined working value, for example about 50°C.
14. A central heating system according to claim 13 having at least one room thermostat (67) to which the burner
30 thermostat (68) is subordinated, the burner thermostat being

adapted to ignite the burner (52) and operate it only while the circulating pump (56) is working, the room thermostat governing the operation of the circulating pump.

- 5 15. A method of operating a water heating apparatus according to claim 5 which includes directing the stream of combustion gases in a first direction along the inner tunnel (70), then in the reverse direction back between (71) the two sets of coils (59,60) and finally between
10 (72) the outer set of coils (60) and the enclosing shell (50) in the original said direction to reach the flue outlet.

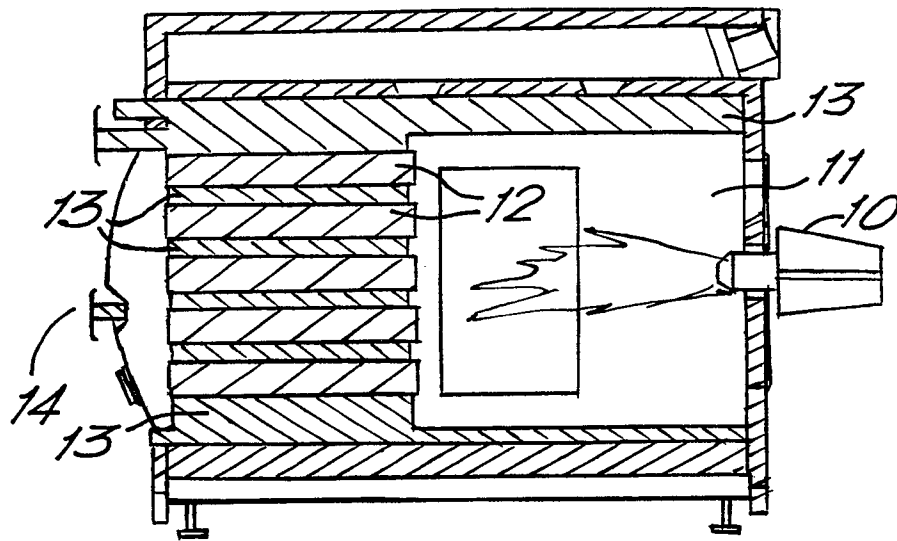


Fig. 1

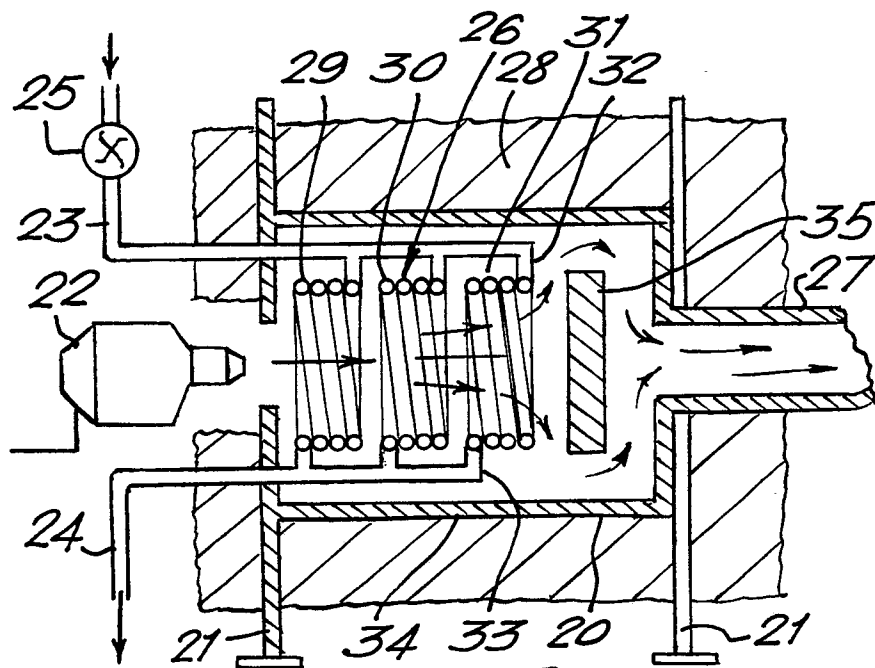


Fig. 2

