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(54) **Boilers for Central Heating Systems**

(57) In heating apparatus for central heating systems which includes a boiler with a discontinuously operating burner, wherein the combustion gases first flow upwardly past a first heat exchanger and then downwardly past a second heat exchanger, the heat exchangers heating up a medium which flows cyclically through an external circuit, the efficiency of the second heat exchanger is enhanced by use of a condenser made of smooth-walled tubing i.e. without fins or ribs, and which is made larger than the first heat exchanger.

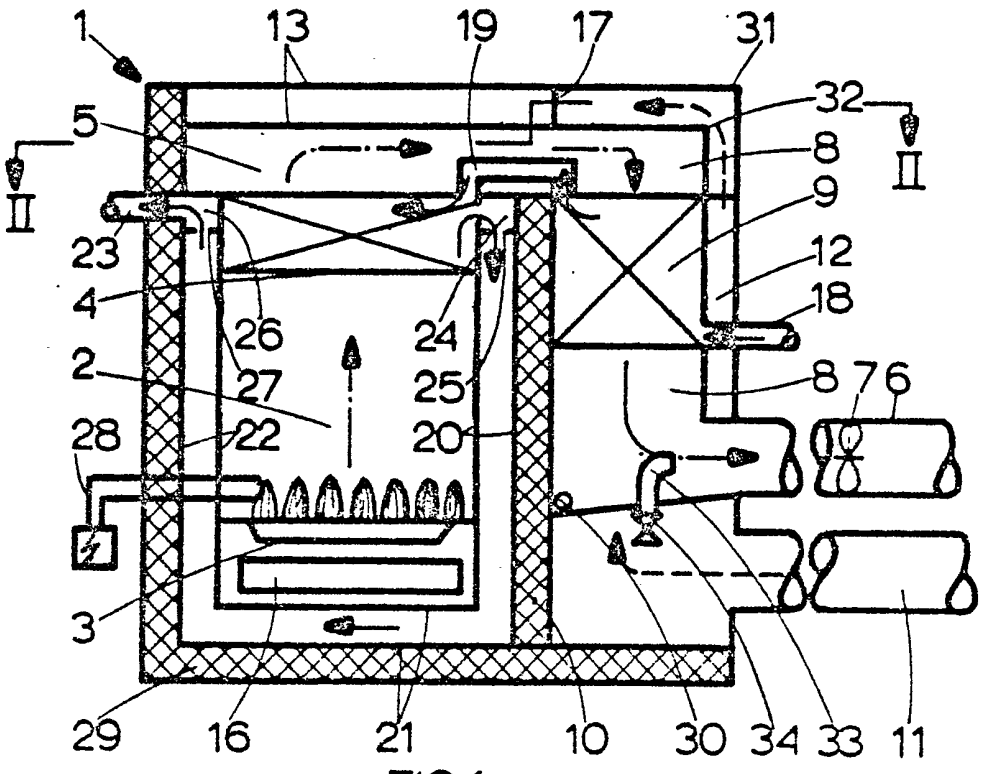

FIG.1

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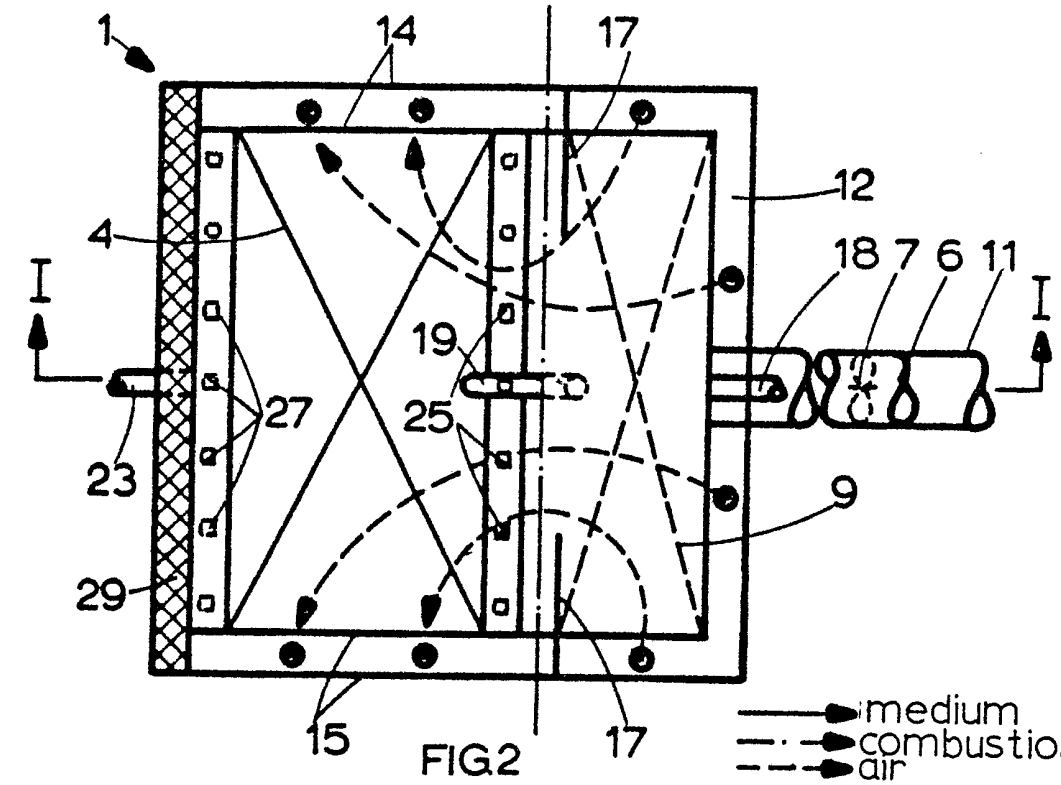
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away from observer

FIG.2

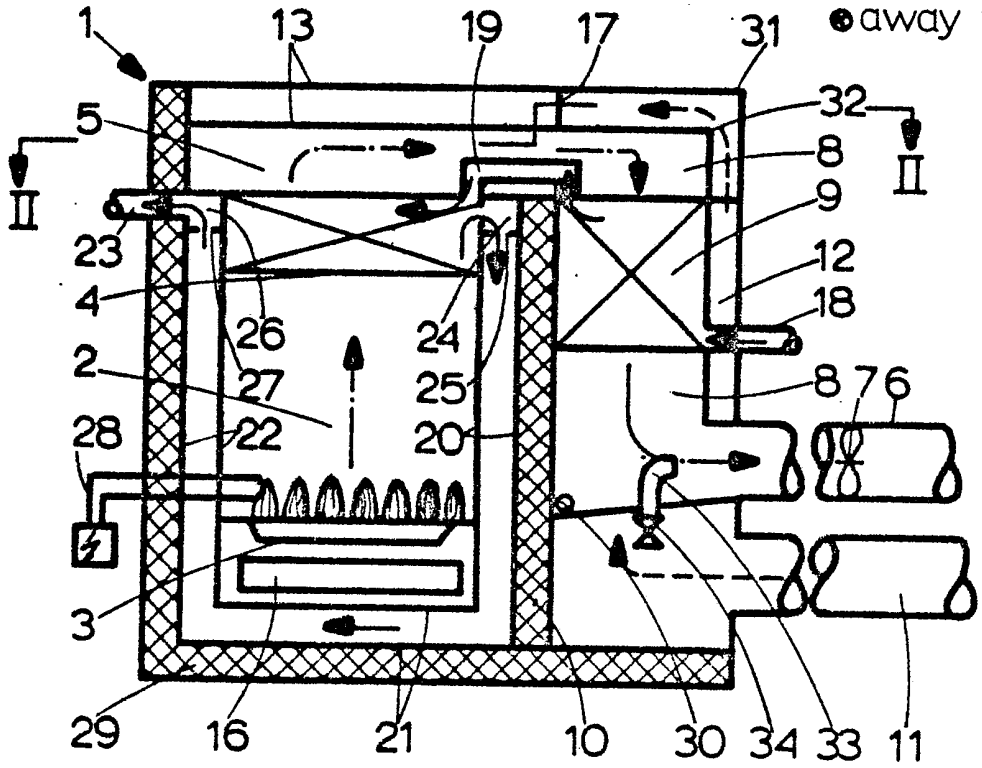
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FIG.1

SPECIFICATION

Heating Apparatus for Central Heating Systems

This invention relates to heating apparatus for central heating systems, which includes a boiler with a discontinuously operating gas or oil firing burner, the said boiler comprising

a) a furnace, a first heat exchanger inserted in the path of combustion gases generated in the said furnace for the heating of a heating medium flowing from the boiler to an external circuit, and a collecting chamber for the said combustion gases, the assembly of furnace, first heat exchanger and collecting chamber constituting an upwardly-directed portion of the flow-path of the combustion gases;

b) arranged adjacent a side wall of the boiler a downwardly-directed portion of the flow-path of the combustion gases, connected to the said collecting chamber, which downwardly-directed portion incorporates a second heat exchanger in the path of the combustion gases flowing therein for preheating by means of the said combustion gases, medium flowing back to the boiler from the said external circuit.

A heating apparatus of this kind is known from Dutch Patent specification A-7700041. The object of providing the flow-path of the combustion gases with an upwardly and downwardly-directed portion is to reduce the heat losses resulting from the draught in the apparatus during the periods the main burner is extinguished.

Dutch Patent specification A-7709476 discloses that with central heating apparatus of this kind it is advantageous to have the heat exchanger in the downwardly-directed portion disposed at a lower level than the heat exchanger in the upwardly-directed portion. This is alleged to promote the maintenance of a thermostatic equilibrium in the channel sections, for which reason also the wall separating the two branches may be designed as a heat transmitting partition. Possibly this is to prevent formation of condensate inside the apparatus.

An object of the present invention is to provide a heating apparatus for heating-up a heating medium as described above, with the special objective of promoting formation of condensate on the second heat exchanger provided in the downwardly-directed portion of the flow-path of the combustion gases so as to recover heat of condensation from the flue gases. Another object is to further raise the efficiency of the apparatus over that attainable by the recovery of condensation heat, by the application of particular measures as hereinafter described.

The invention provides heating apparatus for central heating systems as hereinafter set forth in Claim 1.

A particularly important feature of the invention is the provision, unusual in home heating means, of a condenser made of smooth-walled tubing i.e. without fins or ribs, embodied as the said second heat exchanger.

To keep the external dimensions of the heating apparatus as small as possible, the cross-sectional area of the said downwardly-directed portion of the flow-path of the combustion gases is made as small as possible. Also to provide a sufficiently large area for the second heat exchange and condensation, the heat exchange path of the second heat exchanger is made larger than that of the first heat exchanger, i.e. the heat exchanger has a greater depth.

For constructional reasons and to promote accessibility and ease of dis-assembly for inspection and maintenance, it is preferable to have the tops of the two heat exchangers at about the same level. Owing to the comparatively greater heat exchanger length of the second heat exchanger compared with the first heat exchanger, the stable thermal equilibrium in the situation when the burner does not work is ensured; as the second heat exchanger in particular contributes a comparatively high resistance to the gases passing therethrough, the internal draught is virtually eliminated. The said comparatively high resistance renders necessary the application of forced draught, for which reason the heating apparatus is provided with means for generating a forced draught, e.g. a fan or an ejector.

To optimise the formation of condensate, the downwardly-directed portion of the flow-path of combustion gases should be as cool as possible. This is achieved in a preferred feature of the invention by the provision of thermal insulating means. The term "thermally insulated" is not restricted to total thermal insulation, but should provide at least some protection from the heat of the burner. By this means the downward branch is thermally insulated from the side wall of the boiler which it adjoins so that as little heat as possible is transferred from the boiler to the downward branch. To this end, preferably a layer of insulating material, e.g. glass wool or rock wool, is placed between the boiler wall and the downward branch. It is essential that heating of the cooled combustion gases be prevented as much as possible, which is contrary to the prejudice, widespread among heating technologists, that the discharged combustion gases should always be warm.

Boilers possessing a second heat exchanger on which condensation occurs are known, e.g. from NL-B-158918. The second heat exchanger is in this case on a higher level than the first heat exchanger, and the direction in which the condensate is removed (down) is opposed to the direction of flow of the combustion gases (up), so that the condensate on its downward way encounters ever hotter combustion gases and consequently part of it evaporates again. On the bases of this concept, condensate from the second evaporator is, according to the invention, discharged through a downward, progressively cooler flow of combustion gases, so that evaporation of condensate does not occur. This

idea cannot be derived from the abovementioned NL-A-7709476, which, quite contrarily, indicates that the wall between the upward and the downward branch must, at least in part, transmit heat, and that formation of condensate in the downward branch must be avoided. US-A-2,315,451 describes a boiler with an upward and a downward branch thermally insulated from each other. This is a boiler operating continuously and preferably fired with solid fuel, so that the problem of heat losses occurring when the main burner is extinguished does not occur. The insulation is used for the purpose of preventing disturbance of the useful effect of the heating of the water flowing in counter-current to the flue gases. The insulation used between the two branches in the apparatus according to the present invention should be seen as part of the measures taken to prevent evaporation of water of condensation.

Further cooling of the downward branch can be achieved if at least part of this branch is provided with an air jacket for additional preheating of combustion air flowing to the burner. A preferred embodiment of the heating apparatus according to the invention, in which the downward branch is provided with such an air jacket, is characterized in that the ensemble formed by boiler and collecting chamber for flue gases is double-walled throughout, so that three spaces enclosed by walls form a continuous channel for the transport of medium from the first heat exchanger to the external circuit, and three spaces enclosed by walls form a continuous channel for the transport of combustion air, which communicates with the said air jacket.

The total of provisions incorporated in the abovementioned preferred embodiment of the heating apparatus can be summarized as follows:

1. The downward branch has a cool jacket and the second heat exchanger incorporated in this branch is relatively tall in comparison with the first. Heat losses on account of internal draught when the burner is extinguished are thus virtually eliminated.

2. The downward branch, adjoining a side wall of the boiler, is so insulated from this side wall that the combustion gases form water of condensation on the smooth tubing of the second heat exchanger and in doing so release condensation heat. The water of condensation collects on the bottom of the downward branch, where it does not evaporate again while absorbing heat. The cool jacket promotes condensation.

3. Medium to be heated passing through the spaces enclosed by walls, or combustion air to be heated, flows around the collecting chamber for the combustion gases and the furnace with the first heat exchanger.

These provisions result in an exceptionally favourable heating efficiency if, in addition, all those provisions are employed which normally make for a reasonable efficiency, such as correct adjustment of the fuel-air ratio, and good thermal insulation of the outside of the boiler.

Where mention is made here of a heating medium, not only liquid media, such as water, are meant, but also gaseous media, such as air.

It is also possible for a heating device according to the invention which in itself is designed for heating a liquid medium, such as water, to be used for a hot-air heating system. This embodiment is characterized in that the external circuit contains at least a heat exchanger in which said liquid heating medium can exchange heat with air for a hot-air heating system.

The burner can be equipped with an on-off control as well as with a modulating control. Burner ignition is preferably electric, since there is no draught when the burner is not working, which makes the use of a pilot flame undesirable.

The invention is elucidated with reference to the drawing, which shows a non-restrictive example. In this drawing:

Fig. 1 is a diagrammatic vertical section of a preferred embodiment of the heating apparatus according to the invention, taken along the line I—I in Fig. 2;

Fig. 2 is a diagrammatic horizontal section of this apparatus, along the line II—II in Fig. 1.

The reference numbers in the two figures have the following meanings:

1: a central heating boiler fired with gas or oil;

2: the furnace of the central heating boiler 1;

3: a gas or oil burner in furnace 2;

4: a first heat exchanger in the top of furnace 2, in which the hot combustion gases release part of their heat to a liquid heating medium flowing through this heat exchanger;

5: a collecting chamber for combustion gases; the parts 2, 4 and 5 together form an upward branch for the passage of combustion gases;

6: a discharge for combustion gases;

7: a fan in the discharge 6 for draning off the combustion gases: this fan is required because natural draught is lacking on account of the low temperature of the flue gases; as shown, the fan may be placed near the heating apparatus, but it can also be installed for instance in or on a stack; the electric control of the fan motor is such that the fan is started shortly before each ignition of the burner, in order to flush the furnace with fresh air, and is stopped at about the same time the burner is extinguished, which means that it does not run during almost the whole period the burner does not work, so as to prevent heat losses;

8: a downward branch forming a substantially vertical downward connection between the collecting chamber for combustion gases, 5, and the discharge 6;

9: a second heat exchanger placed in the downward branch 8, in the path of the combustion gases, in which liquid heating medium is preheated by the discharged combustion gases; this heat exchanger is made of smooth-walled tubing, so that the condensation thereon of water vapour from the combustion gases may proceed undisturbed;

10: an insulating layer between the side wall of boiler 1 and the downward branch 8;

11: the inlet for combustion air;

12: an air jacket around the downward branch 8 in which air entering through inlet 11 is preheated;

13: double top wall of collecting chamber for combustion gases 5, the space between the two walls connecting to air jacket 12;

14, 15: double side walls of the ensemble formed by furnace 2 and collecting chamber for combustion gases 5, the spaces between the walls connecting to the space in the double top wall 13, thus forming therewith a continuous transport channel for combustion air that communicates with the air jacket 12;

16: air slot in the inner wall of double wall 14, through which the furnace space 2 communicates with the space in double wall 14, and through which the air preheated in this space is admitted under burner 3; a similar air slot is provided in the inner wall of double wall 15;

17: guides promoting uniform distribution of the air stream in the double top wall 13; the same effect may be reached with differently disposed guides;

18: a feed line for liquid medium returning to the boiler from an external circuit, which line connects to the second heat exchanger 9;

19: a connecting line between the discharge of the liquid-transporting part of the second heat exchanger 1 and the inlet of the liquid-transporting part of the first heat exchanger 4;

20: a double side wall of furnace 2, the space between the two walls connecting to the discharge of the liquid-transporting part of the first heat exchanger 4;

21: a double bottom wall of furnace 2, the space between the two walls connecting to the space in double side wall 20;

22: a double side wall of furnace 2, the space between the two walls connecting to the space in double bottom wall 21; the spaces in double walls 20, 21 and 22 form a continuous transport channel for heating medium;

23: a discharge line for liquid medium flowing to the external circuit;

24: a distributing tube for medium in the top of double-wall space 20, which distributes the inflowing medium uniformly over the width of the space within double wall 20;

25: outlet openings provided at about equal intervals along the length of distributing tube 24;

26: a medium-collecting tube in the top of double wall 22, by which medium to be discharged is uniformly conducted from the entire width of the space in double wall 22 to discharge 23;

27: inlet openings provided at about equal intervals along the length of collecting tube 26;

28: an electric igniter for the burner;

29: insulation of the furnace; if so desired, also the double top wall 13 and the walls 14 and 15 may be provided with insulation;

30: a discharge for water of condensation leading from the bottom of downward branch 8, which bottom is for this purpose sloped towards this discharge; the discharge connects to a water lock (not shown), to prevent aspiration of false air through this discharge 30 into the downward branch 8, in which an unerpressure prevails.

The double-walled collecting chamber for combustion gases, 5, and the top of the downward branch 8 preferably are commonly covered with two removable box-shaped hoods 31 and 32, one (31) forming the outer wall, and the other (32) the inner wall of the collecting chamber for the combustion gases. After the hoods have been detached the heat exchangers 4 and 9 are accessible (for instance for cleaning), without any liquid-transporting parts having to be detached. The guides 17 in the air space between the hoods may be fastened either on the inner hood 31 or in the outer hood 30.

Between the bottom part of the air jacket 12 and the downward branch 8 there is a connection 33 with a valve 34 through which a set quantity of fresh air can be admitted into the bottom of the downward branch 8. The object of this is to reduce the water content of the gases in discharge 6; the combustion gases to be discharged are, according to the invention, essentially cool and virtually saturated with water vapour.

In the drawing the flows of heating medium, combustion gas and air are indicated by means of arrows. The burner 3 can be any suitable type of conventional burner operating at atmospheric pressure; for gaseous fuel it may, for instance, consist of a bed formed by separate bar-shaped burners. Parts that do not directly relate to the invention, for instance the circulation pump for the medium and all other parts belonging to the external circuit, as well as the fuel feed and the equipment for automatic on-off control of the burner 3 and the fan 7, are not shown. When the burner 3 has been extinguished and the fan 7 has been stopped, no fresh air enters furnace 2, for which reason the use of a pilot flame is undesirable; therefore, use is made of electric ignition. Through air feed line 11 outside air as well as air from the building to be heated can be aspirated. The discharge for combustion gases, 6, can be connected to a stack, but also to a wall-discharge outlet.

An actual prototype of the heating apparatus according to the invention, fired with natural gas and having a heating capacity of 16 kW, suitable for a dwelling house with about 150 sq.m. floor space, has the external dimensions (depth × width × height) 48×42×56 cm. With the aspirated air having a temperature of 20°C, a heating efficiency of 87—97 % was measured, which is about 20—25 % better than the value generally accepted as a fair efficiency for conventional central heating boilers. The higher efficiency figure mentioned above relates to the situation early and late in the heating season, when the medium (water in this particular case) enters the boiler at 20°C and leaves it at 40

°C; the lower value is attained in freezing weather, with temperatures of inflowing and outflowing water of 60 °C and 80 °C, respectively. The efficiencies here given relate to the gross calorific value of the fuel.

The 'standstill losses' are nil with a heating apparatus according to the invention. This means that the practical efficiency (i.e. the efficiency calculated over all temperature fluctuations throughout the heating season) will be equal to the efficiency on the water side at full load. This implies that a certain degree of over-dimensioning of the boiler does not involve extra losses. As within certain limits the dimension-related cost of the boiler does not have a decisive effect on the production cost of the boiler, a smaller range of boilers will suffice, which is commercially advantageous.

Claims

1. Heating apparatus for central heating systems, which includes a boiler with a discontinuously operating gas or oil firing burner, the said boiler comprising

a) a furnace, a first heat exchanger inserted in the path of combustion gases generated in the said furnace for the heating of a heating medium flowing from the boiler to an external circuit, and a collecting chamber for the said combustion gases, the assembly of furnace, first heat exchanger and collecting chamber constituting an upwardly-directed portion of the flow-path of the combustion gases;

b) arranged adjacent a side wall of the boiler a downwardly-directed portion of the flow-path of the combustion gases, connected to the said collecting chamber, which downwardly-directed portion incorporates a second heat exchanger in the path of the combustion gases flowing therein for preheating by means of the said combustion gases, medium flowing back to the boiler from the said external circuit; characterised in that

c) the said downwardly-directed portion (8) of the flow-path of combustion gases is thermally insulated from the said side wall (20) of the boiler;

d) the said second heat exchanger is formed of smooth-walled tubing and has a heat exchange length longer than that of the said first heat exchanger (4);

e) the said downwardly-directed portion of the flow-path of combustion gases is provided with a discharge (30) for water condensed on the outside surface thereof from cooled combustion gases;

f) discharge means (6) for the discharge of cool combustion gases and incorporating means for generating a forced draught (7) in the said discharge means and controlled whereby they are started each time before the burner (13) is ignited and stopped after the burner has been extinguished.

2. Heating apparatus according to Claim 1, characterised in that the said downwardly-directed portion (8) is thermally insulated from the said side wall (20) of the boiler by a layer of insulating material (10).

3. Heating apparatus according to Claim 1 or Claim 2, characterised in that at least part of the said downwardly-directed portion (8) is provided with an air jacket (12) for preheating combustion air flowing to the burner.

4. Heating apparatus according to Claim 3, wherein the assembly formed by boiler (1) and collecting chamber for flue gases (5) is double-walled throughout, so that three spaces enclosed by walls form a continuous channel for the transport of medium from the first heat exchanger to the external circuit, and three spaces enclosed by walls form a continuous channel for the transport of combustion air, which communicates with the said air jacket (12).

5. Heating apparatus according to claim 4, characterized in that the double-walled collecting chamber for combustion gases (5) and the top of the downward branch (8) are commonly covered with two removable box-shaped hoods (31 and 32), one (31) forming the outer wall and the other (32) the inner wall of the collecting chamber for combustion gases and of the top part of the downward branch.

6. Heating apparatus according to one or both of the claims 4 and 5, characterized in that the space enclosed by walls which connects to the medium-transporting part of the first heat exchanger is provided with a distributing tube for medium (24) comprising outlet openings (25) spaced at about equal intervals along its length, which openings can distribute the inflowing medium uniformly over the width of the space between the walls.

7. Heating apparatus according to one or more of the claims 4—6, characterized in that the space enclosed by walls which connects to the external circuit is provided with a medium-collecting tube (26) comprising inlet openings (27) spaced at about equal intervals along its length, by which openings the medium to be discharged can, from the entire width of the space enclosed by walls, be uniformly conducted to the external circuit.

8. Heating apparatus according to one or more of the preceding claims, characterized in that the bottom part of the downward branch (8) is provided with a freshair feed (33, 34) which can be set to admit a predetermined quantity of air.

9. Heating apparatus according to one or more of the preceding claims, characterized by means for on-off control of the burner.

10. Heating apparatus according to one or more of the claims 1—8, characterized by means for modulating control of the burner.

11. Heating apparatus according to one or more of the claims 1—10, characterized by an electric igniter (28) for the burner.

12. Heating apparatus according to one or more of the claims 1—11 and designed for heating a liquid heating medium, this apparatus being characterized in that the external circuit contains at least a heat exchanger in which the

liquid heating medium can exchange heat with air for a hot-air heating system.

13. Heating apparatus as claimed in claim 1, substantially as hereinbefore described and illustrated in the accompanying drawings.

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