Oct. 13, 1953 E. T. LINDEROTH 2,655,205

REGENERATIVE HEATING APPARATUS

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Fig. 1.

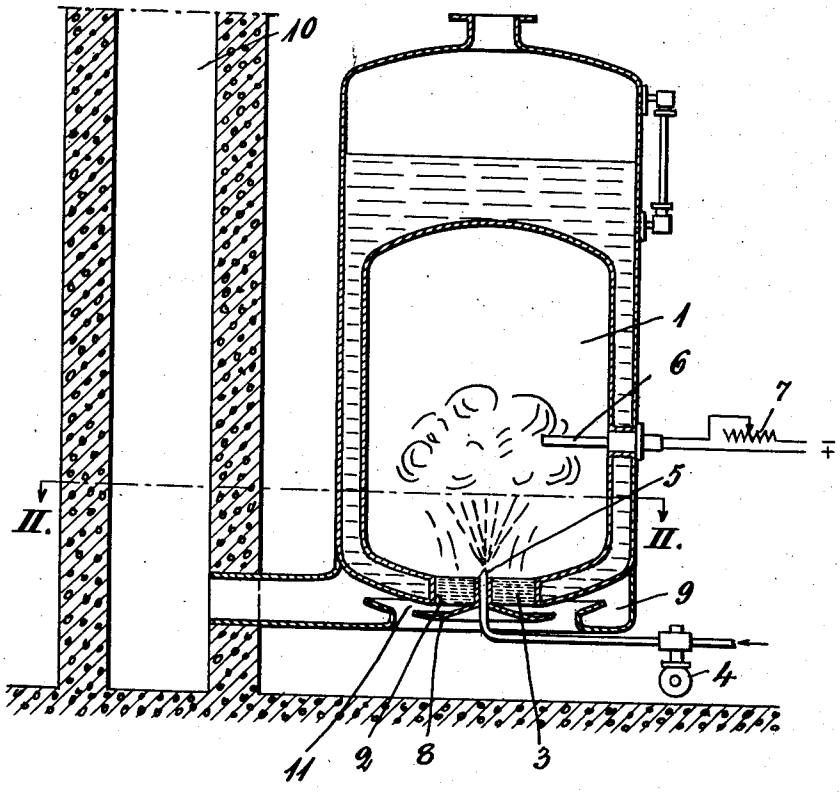

Fig. 2.

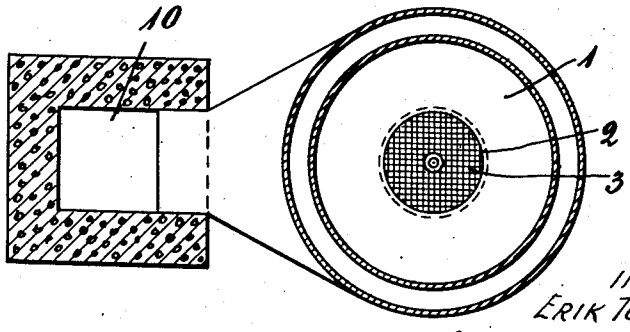

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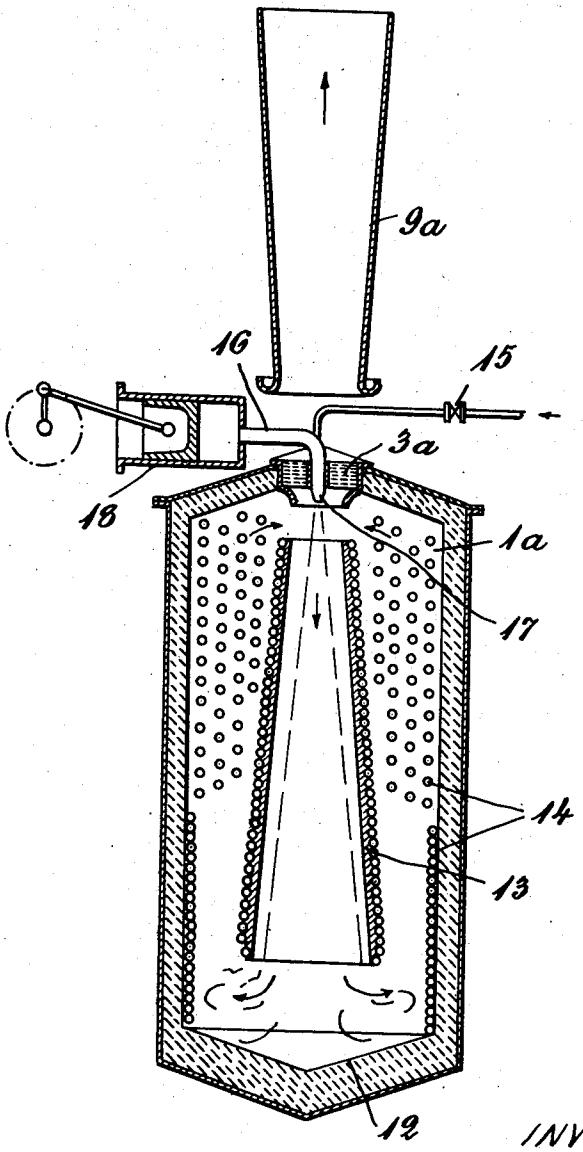
Fig. 3.



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REGENERATIVE HEATING APPARATUS

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9 Claims. (Cl. 158—4.5)

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The present invention relates to a heating apparatus provided with a regenerator, said heating apparatus being suitable for use with a boiler preferably intended for steam or hot water production.

The invention comprises a combustion device in which intermittent combustion takes place, and in which the combustion chamber alternately breathes inwardly and outwardly through a regenerator or other heat exchanging means, without the use of any valves. Burnt gases pass outwardly and combustion air is drawn inwardly through the regenerator alternately, a transfer of heat from the burnt gases to the combustion air being effected by heat from the burnt gases which is stored in the regenerator and subsequently imparted to the incoming combustion air by reason of the temperature difference between the incoming and outgoing gaseous fluids. In regenerative heat transmission of this character, it is possible to give the heat transmitting surface an extremely effective shape with respect to its heat storage and transmitting capacity. The previous disadvantage has been that said surface should be movable or be provided with complicated sluicing means for making possible the alternate flow of air and flue gas.

A combustion device breathing through the regenerator in the manner suggested above involves a great simplification.

A necessary condition for proper operation of a combustion device of this character is that the volume of the regenerator and that of its gas passages shall be very small, so that the volumes of burnt gases and combustion air which fail to pass completely through the regenerator will be minimized. Since the volumes of these gaseous fluids which pulsate in and out through the regenerator is but a small fraction of the volume of the combustion chamber, calculation will indicate that the maximum volume for the heat transfer passages of the regenerator is 5% of the volume of the combustion chamber and preferably less than 1 or 2% of the combustion chamber volume.

Moreover, arrangements should be made to prevent too great a mixture between the fresh air drawn in and remaining combustion products. According to the invention this is effected by the breathing aperture being arranged in the lower part of the combustion chamber in such a way that the fresh air flows in with a moderate velocity in such a direction that the thermo-circulation in the combustion chamber is facilitated, or alternatively, guide members may be provided

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and disposed within the combustion chamber, said guide members being so shaped and located that they catch the incoming air flowing through the regenerator and convey it to the opposite end of the combustion chamber.

In the latter case the breathing through the regenerator will be independent of the cooperation of the thermo circulation, and the breathing aperture may for instance be located in the upper part of the furnace, provided the incoming air flow has a sufficiently high velocity.

In boilers embodying the invention and subject to widely varying loads the first mentioned device is preferred.

Fig. 1 is a vertical sectional view of one form of the invention,

Fig. 2 is a sectional view taken on the line II—II of Fig. 1, and

Fig. 3 is a vertical sectional view of a modification of the invention.

Figs. 1 and 2 illustrate a boiler with such a first mentioned device. The cylindrical combustion chamber 1, which has thermally conductive walls for the transfer of heat therethrough for utilization in heating the water which surrounds these walls, is entirely closed, except for a circular aperture 2 in which a heat exchanging regenerator 3 is mounted. The regenerator is preferably made of fine wires in the form of a plurality of spaced layers of fine mesh netting, so that heat transmission between the layers is prevented as much as possible. When the combustion chamber breathes through the regenerator a temperature is obtained which successively falls in stages from one layer of netting to the next in the direction of the gas flow and successively rises in stages in the direction of the air flow.

With such a regenerator it is possible to cool the flue gas to a few degrees above the temperature of the incoming combustion air. An ample surplus of air may be used for the combustion, without this causing any considerable losses in exhaust heat, and will provide the necessary conditions for complete combustion. Thus a high overall efficiency is made possible.

The combustion chamber of the boiler is adapted to be fired with liquid fuel, which is intermittently injected by a pump 4 through a nozzle 5. Control is effected by changing the timing of the interval between the pump strokes or by varying the length of the pump stroke or both.

The injected fuel is ignited by means of an electric glow plug 6, to which current is supplied through an adjustable resistance 7.

After the intermittent combustion has been

started, the ignition current may be cut off as the combustion keeps the ignition plug glowing. Only at a very low load on the boiler will the ignition plug have to be supplied with a small amount of current. The control for the glow plug should preferably be connected to the fuel pump control, so that the ignition current is automatically supplied when a small quantity of fuel is injected. There is a possibility of arranging a catalytically operating ignition member, whereby the ignition current may be dispensed with, if the combustion is started with a fuse.

The flue gas which is intermittently discharged during the operation of the device is shaped by a round shield 8, on the outside of the regenerator, into an annular jet, which is diverted into an annular collecting chamber 9 from which it is conveyed to the flue or chimney 10. The latter is here entirely relieved of any duty of generating a draught and is only required to deliver the flue gas to the exterior.

During the suction period air is drawn in through an annular slot 11 and is distributed systematically over the regenerator whilst flowing to the furnace. A symmetric distribution of gas and air through the regenerator is prerequisite for utilizing small differences of temperature without causing condensation of the moisture content of flue gases on the heat transmitting surfaces of the regenerator.

Figure 3 shows an embodiment of a modified form of the invention, in which a regenerator 3*a* is disposed at the upper end of a vertical cylindrical combustion chamber 1*a*. The burnt gases expelled from combustion chamber 1*a* pass upwardly through regenerator 3*a* and are caught by an upwardly and outwardly flaring chimney 9*a*, operating as a diffuser which conveys the burnt gases to the flue (not shown).

In this case, the regenerator should be so dimensioned as to cause relatively high velocities of air and burnt gas flow in and out through the regenerator, thus permitting the incoming combustion air to be shaped as a downwardly directed jet capable of penetrating to the bottom of the combustion chamber where there is provided an upturned "ignition arch" 12. In order to prevent the incoming air jet from mixing immediately with the surrounding burning gases, a downwardly and outwardly flaring frusto-conical guide member or diffuser 13 is mounted within the combustion chamber 1*a* with its smaller upper end in proximity to the regenerator 3*a*. This guide member is preferably formed as a heat transmitting surface. As the heat transmitting surface 14 of the boiler as a whole here is suggested to be in the form of pipe coils the guide means 13 should also preferably be in the form of a tight-wound pipe coil and may be provided with an inner coating of refractory or other suitable fireproof material.

Fuel is continuously supplied through a control valve 15 to a vertically directed portion of a pipe 16 which passes centrally through the regenerator 3*a* into the upper end of the combustion chamber 1*a*. Pipe 16 is provided at its lower end with a nozzle 17, through which the gas in the furnace is pumped in and out by means of a piston pump 18, which in this case should not have any valves.

In this way there will be no unidirectional flow through the regenerator, which otherwise would be the case, should the fuel be atomized by means of compressed air supplied from the exterior of the furnace. A slight blast action is required by the burner in order to start an inverted combustion of this kind. When the breathing of the furnace has been well started, the circulation is maintained in the desired direction by the intermittently drawn in air which is shaped into a downwardly directed jet diffused by guide member 13. The combustion is started by throwing a burning fuse onto the bottom of the furnace.

This type of combustion device may also be arranged to be fueled with pulverized coal. It may also be constructed for fitting the breathing aperture in its lower end which however, naturally causes changes in the other devices, for instance in accordance with Fig. 1.

Having now particularly described the nature of my invention and the manner of its operation what I claim is:

1. Heating apparatus of the class described, comprising: a combustion chamber having an aperture therein, said combustion chamber being otherwise closed, said combustion chamber comprising thermally conductive walls through which heat may be transferred for utilization; gas permeable heat exchanging means disposed in said aperture for alternate passage therethrough of combustion air and burnt gases; intermittently operating means for injecting fuel into said chamber for periodically producing a combustible mixture therein; means for igniting said combustible mixture; a flue for carrying away the burnt gases; and means for directing burnt gases from said heat exchanging means into said flue, whereby heat will be transferred from said burnt gases to said heat exchanging means during passage of said burnt gases therethrough, and from said heat exchanging means to air entering said combustion chamber as the burnt gases remaining in the combustion chamber contract by transfer of heat to said thermally conductive walls.

2. Heating apparatus according to claim 1, wherein said gas permeable heat exchanging means comprises a plurality of spaced layers of wire mesh netting.

3. Heating apparatus according to claim 1, wherein said fuel injecting means comprises a nozzle disposed centrally with respect to said heat exchanging means.

4. Heating apparatus according to claim 1, wherein said aperture is disposed in the top of said combustion chamber, and further comprising guide means disposed within said combustion chamber for directing said combustible mixture toward the bottom of said combustion chamber, said guide means comprising a downwardly extending hollow frusto-conical guide member including a heat transfer surface, said guide member being disposed with the smaller end of said frusto-conical configuration located in proximity to said heat exchanging means.

5. Heating apparatus according to claim 1, wherein said aperture is disposed in the bottom of said chamber, and wherein said burnt gas directing means comprises a round shield disposed beneath said aperture for shaping the burnt gases into an annular jet and an annular collecting chamber is connected to said flue and encircles said round shield and is spaced therefrom to provide an annular opening for the admission of air to said heat exchange means.

6. Heating apparatus according to claim 1, in which said igniting means comprises: a glow plug; an electrical circuit for energizing said glow plug; and adjusting means in said electrical circuit for controlling the energization of said glow plug, whereby said igniting means may

be controlled for ignition of said combustible mixture at times when the thermal load supplied by said heating apparatus is reduced.

7. Heating apparatus according to claim 1, wherein said intermittently operating fuel injecting means comprises: a valveless reciprocating plunger pump; a pipe connecting said pump to said combustion chamber; and a controllable fuel supply line communicating with said pipe.

8. Heating apparatus according to claim 7, wherein said heat exchanging means is disposed at the top of said combustion chamber, said pipe passes centrally through said heat exchanging means into said combustion chamber, and in which said pipe terminates in a downwardly directed nozzle.

9. Heating apparatus according to claim 1, wherein said aperture is disposed in the top of said combustion chamber, and in which said thermally conducting walls include the walls of pipes carrying fluid to be heated, further comprising a downwardly extending hollow frusto-conical guide member disposed within said combustion chamber, said guide member being formed at least in part by said pipes and having the smaller end of said frusto-conical configuration disposed in proximity to said heat exchanging means, said guide member directing said combustible mixture toward the bottom of said combustion chamber.

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