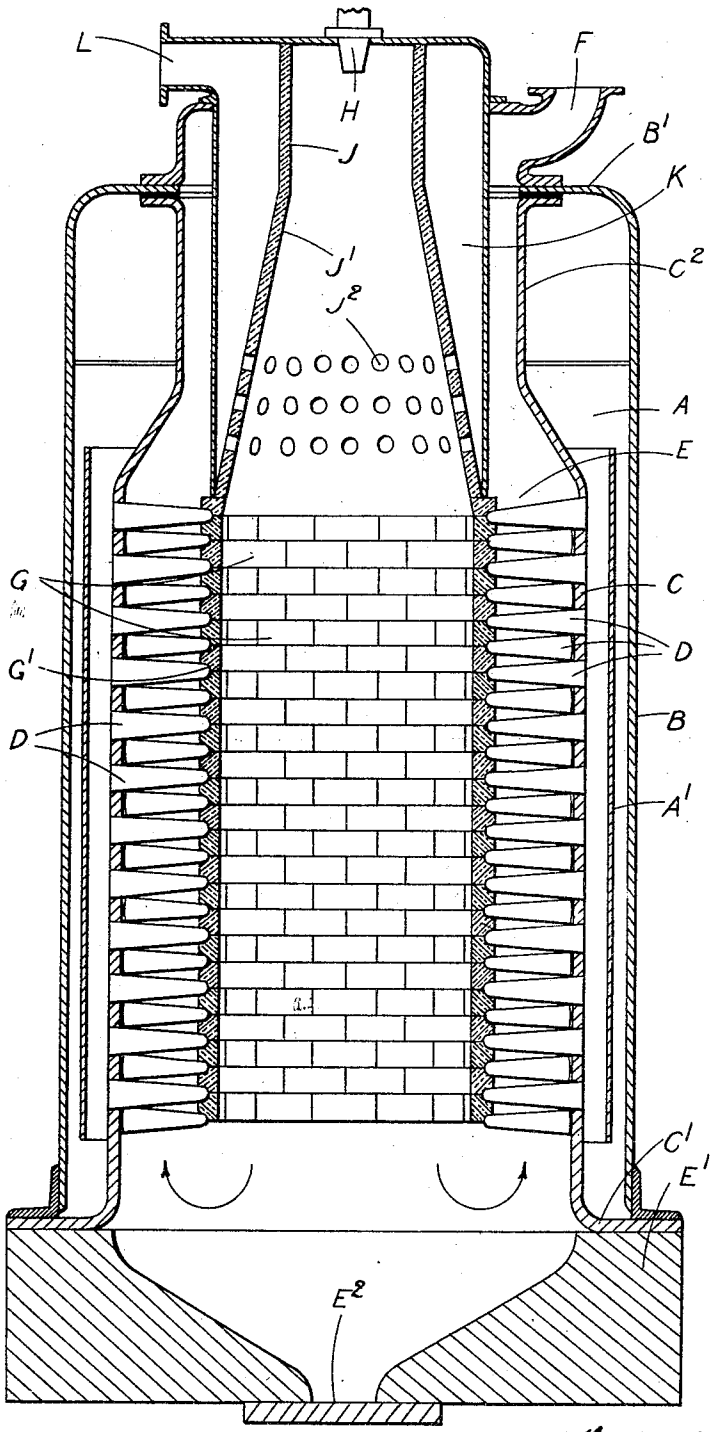
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STEAM GENERATOR OR WATER HEATER

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# UNITED STATES PATENT OFFICE

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## STEAM GENERATOR OR WATER HEATER

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This invention relates to steam generators or water heaters of the kind comprising a vertically arranged annular chamber for water or water and steam from the inner circumferential wall of which a series of closed-ended water tubes radiate into a central heating space one end of which is closed. In such generators or water heaters hot gases from a burner or other source are delivered to the heating space through a tubular member (hereinafter termed a tubular combustion member) extending into the heating space from the outer end of the latter towards the closed end whence these hot gases flow back through the annular space surrounding the tubular combustion member and occupied by the thimble tubes to an outlet opening at the outer end of the heating space.

The object of the present invention is to provide an improved steam generator or water heater of the above general type, particularly but not exclusively for use in larger sizes than has hitherto been usual for generators of this type, which will be simple and inexpensive to construct and efficient in operation.

To this end according to the present invention, a steam generator or water heater of the above type is provided with a tubular combustion member built up of bricks or the like of refractory material and supported by the free ends of the thimble tubes which project radially inwards from the inner wall of the water chamber.

Preferably the tubular combustion member is formed of a series of separate superimposed rings, each of which is built up of a series of segmental or other shaped bricks or the like of refractory material, each ring being directly in contact with and carried by the free ends of the thimble tubes which engage it. Thus the bricks or pieces of refractory material of which the tubular combustion member is formed are conveniently so constructed that when in place the ends of the thimble tubes project into recesses or the like in the substance of which the tubular member is formed while the inner surface of this member is substantially smooth and continuous.

Thus where, as is preferred, the tubular combustion member comprises a series of superimposed rings, each ring is conveniently constructed externally with recesses or annular grooves therein so that, when in place, the end of each thimble tube will be enclosed in or lie between refractory material with which it is in intimate contact, while the abutting edges of adjacent bricks are formed so as to engage each other in such a manner that each ring as a whole will be supported solely by the ends of the thimble tubes with which it lies in contact.

Hot gases from the burner or other source are preferably delivered to the tubular combustion member thus formed through a further tubular member which extends from near the burner or the like to the adjacent end of the built-up combustion member, the part of this tubular extension lying adjacent to the burner conveniently being tapered.

Further, the formation of the closed end of the heating space, i. e. that remote from the burner, wherein the hot gases issuing from the tubular combustion member are deflected so that their direction of flow is reversed and they pass backwards over the thimble tubes along the outside of the tubular combustion member, is preferably such as to assist this reversal in the direction of flow of the gases while a detachable cover or door may be provided in this closed end to allow of access to the combustion space, for example for the removal of ash or slag deposited by the gases as their direction of flow is reversed. The formation of the closed end of the heating space may vary but it is preferably substantially conical and constructed of refractory material, although in some cases it may be formed of metal and used as a heating surface with a water space behind it.

The invention may be carried into practice in various ways but one construction of steam generator or water heater according to this invention is illustrated somewhat diagrammatically in sectional elevation by way of example in the accompanying drawing.

In the construction illustrated, the gener-

ator or water heater comprises a chamber A for water or water and steam formed from two coaxially arranged tubular members B and C of different diameters connected together at their ends by flange-like parts $B^1$, $C^1$ as shown. The upper end $C^2$ of the inner tubular member C is reduced somewhat in diameter so as to increase the cross-sectional area of this part of the chamber A.

From the portion of the inner wall C of the chamber A which lies below the reduced portion $C^2$ a series of thimble tubes D radiate inwards into a heating space E, the lower end of this heating space being closed by a member $E^1$ constituting the base on which the generator as a whole is supported, while the upper end of the heating space communicates with an outlet pipe F for hot gases.

The thimble tubes D are aranged in a series of circumferential rows as shown and supported by the free ends of the thimble tubes in each row is a ring of refractory material built up from a series of segmental or other shaped bricks G. As shown in the drawing each of the rings constituted by the bricks G is provided on both its upper and lower surfaces with a similar annular groove or recess $G^1$ in which lie the inner ends of the tubes in the rows respectively immediately above and immediately below such ring, each of the rings thus being placed between two adjacent rows of thimble tubes and being supported on the free ends of the lower row and formed so that the free ends of the upper row are partially accommodated therein.

The inner surfaces of all the rings are smooth so that these rings together form a continuous tubular combustion member in the outer surface of which the free ends of the thimble tubes are in effect embedded.

Hot gases are delivered to the tubular combustion member from a downwardly directed burner H situated at the upper end of the generator, these gases being delivered through a tubular extension J the lower end of which engages the uppermost ring of bricks G and is conveniently provided with an annular recess similar to the recesses $G^1$ to accommodate the upper portion of the ends of the thimble tubes D in the uppermost row as shown. The upper end of the tubular member J lies adjacent to the burner H, this tubular member conveniently being tapered as shown at $J^1$ and provided with perforations $J^2$ in this tapered portion through which air can pass from a chamber K surrounding the member J and communicating with a fan or blower or with the atmosphere through a pipe or passage L.

The hot gases of combustion after passing downwards through the member J, $J^1$ and the tubular combustion member constituted by the bricks G are deflected by the lower closed end $E^1$ of the heating space and reverse their direction of motion, passing upwards through the annular space E surrounding the tubular combustion member and containing the thimble tubes and thence through the upper end $C^2$ of the member C to the outlet passage F. Thus these hot gases are caused to flow over and around the thimble tubes D so as to impart heat thereto and hence to the water in the chamber A, while additional heat is imparted to the tubes D by the tubular combustion member in which their inner ends are embedded.

The lower closed end $E^1$ of the heating space is conveniently formed curved or substantially conical as shown and is preferably provided at or adjacent to its centre with a removable cover indicated at $E^2$ through which access can be had to the heating space, for example, for enabling deposit to be removed.

Arranged in the water chamber A is a cylindrical baffle $A^1$ adapted to assist circulation of the water which tends to flow upwards inside the baffle and downwards outside it.

The material of which the bricks forming the tubular combustion member are constructed may vary but preferably is some such material as carborundum of a refractory but not a heat insulating character. Thus when a construction according to this invention such as that illustrated in the accompanying drawings is employed, the tubular combustion member may become incandescent and heat will be readily conducted through the wall thereof and transmitted to the thimbles through the ends of these thimbles which are in contact with the wall. Heat will also be radiated from the outer surface of the wall on to the opposite wall of the water chamber and the thimble tubes.

Thus as combustion takes place and is completed within the incandescent tube, the fuel is not exposed to any black wall during the combustion process, whereby the combustion process is improved and intensified enabling the rate of combustion per pound of fuel per cubic foot of furnace volume to be correspondingly increased.

Further, during the return flow of the hot gases over the thimble tubes at high velocity when they transmit heat to the water in these tubes and the water chamber by convection, the radiant heat from the outer incandescent wall of the tubular combustion member will be transmitted across the space through which the gases flow without imparting any considerable heat to the gases themselves so that the temperature of these gases gradually falls as they pass through the heating space and give up heat to the water chamber and thimble tubes. These gases thus leave the heating space in a comparatively cool condition having regard to the intense rate of combustion made possible by the incandescent combustion tube.

It is to be understood that although the

invention has been described with particular reference to a generator of the type in question in which the lower end of the heating space is closed and the hot gases enter and leave this space at the upper end thereof, it may be applied equally to a generator of this type in which the hot gases enter and leave the heating space from the lower end thereof and the upper end of the heating space is closed without departing from this invention.

What I claim as my invention and desire to secure by Letters Patent is:—

1. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of this heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a built-up tubular combustion member formed of refractory material supported on the inner ends of the water tubes, and means for delivering hot gases through the end of the tubular combustion member which lies adjacent to the open end of the heating space.

2. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of this heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member built up from a series of blocks of refractory material supported on the inner ends of the water tubes, and means for delivering hot gases through the end of the combustion member which lies adjacent to the open end of the heating space.

3. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a built-up tubular combustion member formed of refractory material and supported on and in direct contact with the inner ends of the water tubes, and means for delivering hot gases through the end of the tubular combustion member which lies adjacent to the open end of the heating space.

4. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member supported on the inner ends of the water tubes and comprising a series of superimposed rings each built up of a number of blocks of refractory material, and means for delivering hot gases through the end of the tubular combustion member which lies adjacent to the open end of the heating space.

5. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member built up from a series of blocks of refractory material and having depressions in its outer circumferential surface which are engaged by and accommodate within them the inner ends of the water tubes so that the tubular combustion member is supported by and in direct contact with the water tubes, and means for delivering hot gases through the end of the tubular combustion member which lies adjacent to the open end of the heating space.

6. A water heater including in combination a vertically arranged annular water chamber surounding a central heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the central heating space, a tubular combustion member supported on the inner ends of the water tubes and comprising a series of superimposed rings each built up of blocks of refractory material and having depressions in their outer surfaces into which extend the inner ends of the water tubes so that the rings are supported by and are in direct contact with the water tubes, and means for delivering hot gases through the end of the tubular combustion member which lies adjacent to the open end of the heating space.

7. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a built-up tubular combustion member formed of refractory material and supported on the inner ends of the water tubes, a tubular extension arranged coaxially with the tubular combustion member and extending from the end thereof to a point adjacent to the open end of the heating space, and a fuel burner directing a flame through this tubular extension into the tubular combustion member, the hot gases from the burner after passing through the tubular combustion member reversing their direction of motion and returning over the outside of the tubular combustion member through the annular space in which lie the water tubes and finally flowing out through the part of the heating space surrounding the tubular extension.

8. A water heater including in combina-

tion a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member built up from a series of blocks of refractory material and supported on the inner ends of the water tubes, a tubular extension arranged coaxially with the tubular combustion member and extending from the end thereof to a point adjacent to the open end of the heating space, and a fuel burner directing a flame through this tubular extension into the tubular combustion member, the hot gases from the burner after passing through the tubular combustion member reversing their direction of motion and returning over the outside of the tubular combustion member through the annular space in which lie the water tubes and finally flowing out through the part of the heating space surrounding the tubular extension.

9. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member built up from a series of blocks of refractory material and having depressions in its outer surface into which extend the inner ends of the water tubes so that the tubular combustion member is supported by and in direct contact with the water tubes, a tubular extension arranged coaxially with the tubular combustion member and extending from the end thereof to a point adjacent to the open end of the heating space, and a fuel burner directing a flame through this tubular extension into the tubular combustion member, the hot gases from the burner after passing through the tubular combustion member reversing their direction of motion and returning over the outside of the tubular combustion member through the annular space in which lie the water tubes and finally flowing out through the part of the heating space surrounding the tubular extension.

10. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a built-up tubular combustion member formed of refractory material and supported on the inner ends of the water tubes, a tubular extension having perforations in its wall arranged coaxially with the tubular combustion member and extending from the end thereof to a point adjacent to the open end of the heating space, a fuel burner directing a flame through this tubular extension into the tubular combustion member, and an annular air chamber surrounding the tubular extension and from which air can flow through the perforations in the wall of the latter, the hot gases from the burner after flowing through the tubular combustion member reversing their direction of motion and returning over the outside of the tubular combustion member through the annular space containing the water tubes and finally flowing over the exterior of the air chamber.

11. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member built up from a series of blocks of refractory material and having depressions in its outer circumferential surface into which extend the inner ends of the water tubes so that the tubular combustion member is supported by and in direct contact with the water tubes, a tubular extension having perforations in its wall arranged coaxially with the tubular combustion member and extending from the end thereof to a point adjacent to the open end of the heating space, a fuel burner directing a flame through this tubular extension into the tubular combustion member, and an annular air chamber surrounding the tubular extension and from which air can flow through the perforations in the wall of the latter, the hot gases from the burner after flowing through the tubular combustion member reversing their direction of motion and returning over the outside of the tubular combustion member through the annular space containing the water tubes and finally flowing over the exterior of the air chamber.

12. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes extending radially inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member arranged within the heating space between the inner ends of the water tubes, a tubular extension having perforations in its wall extending from the end of the tubular combustion member to a point adjacent to the open end of the heating space, a fuel burner for delivering hot gases through this extension to the tubular combustion member, and an air chamber surrounding the tubular extension and from which air can flow through the perforations in the wall of this extension, the hot gases from the burner after flowing

through the tubular combustion member reversing their direction of flow and returning over the exterior of the tubular combustion member through the space in which lie the water tubes and finally flowing through the annular portion of the heating space surrounding the air chamber.

13. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for the lower end of the heating space having a conical inner wall, an outlet opening in this closure, means for closing the outlet, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a built-up tubular combustion member formed of refractory material and supported on the inner ends of the water tubes, and means for delivering hot gases through the upper end of the tubular combustion member.

14. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for the lower end of the heating space, an opening in this closure, means for closing this opening, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a built-up tubular combustion member formed of refractory material and supported on and in direct contact with the inner ends of the water tubes, and means for delivering hot gases through the upper end of the tubular combustion member.

15. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for the lower end of the heating space having a conical inner surface, a central opening in this closure, means for closing this opening, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member built up from a series of blocks of refractory material and having depressions in its outer circumferential surface which are engaged by and accommodate within them the inner ends of the water tubes so that the tubular combustion member is supported by and in direct contact with these tubes, and means for delivering hot gases through the upper end of the tubular combustion member.

16. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for one end of the heating space, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member built up from a series of blocks of refractory material and having depressions in its outer circumferential surface which are engaged by and accommodate within them the inner ends of the water tubes so that the tubular combustion member is supported by and in direct contact with such tubes, a conical tubular extension arranged coaxially with the tubular combustion member and extending from the end thereof to a point adjacent to the open end of the heating space, and a fuel burner directing a flame through this tubular extension into the tubular combustion member, the hot gases from the burner after passing through the tubular combustion member reversing their direction of motion and returning over the outside of the tubular combustion member through the annular space in which lie the water tubes and finally flowing out through the part of the heating space surrounding the tubular extension.

17. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for the lower end of the heating space having a conical inner surface, a central opening in this closure, means for closing this opening, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the central heating space, a tubular combustion member supported on the inner ends of the water tubes and comprising a series of superimposed rings each built up of blocks of refractory material and having depressions in their outer surfaces into which extend the inner ends of the water tubes so that the rings are supported by and are in direct contact with the water tubes, and means for delivering hot gases through the end of the tubular combustion member which lies adjacent to the open end of the heating space.

18. A water heater including in combination a vertically arranged annular water chamber surrounding a heating space, a closure for the lower end of the heating space having a conical inner surface, a central opening in the closure, means for closing this opening, a series of closed-ended water tubes radiating inwards from the inner circumferential wall of the water chamber into the heating space, a tubular combustion member built up from a series of blocks of refractory material and having depressions in its outer circumferential surface which are engaged by and accommodate within them the inner ends of the water tubes so that the tubular combustion member is supported by and in direct contact with these tubes, a tubular extension having perforations in its wall extending from the upper end of the tubular combustion member to a point adjacent to the open upper end of the heating space, an air chamber surrounding this tubular extension and from which air can pass through the perforations in the wall of the latter, and a fuel burner directing a flame through the tubular extension into the tubular combus-

tion member, the hot gases from the burner after passing through the tubular combustion member reversing their direction of motion and returning over the outside of the tubular combustion member through the annular space in which lie the water tubes and finally flowing through the portion of the heating space surrounding the air chamber.

In testimony whereof I have signed my name to this specification.

THOMAS CLARKSON.