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FLUID HEATER

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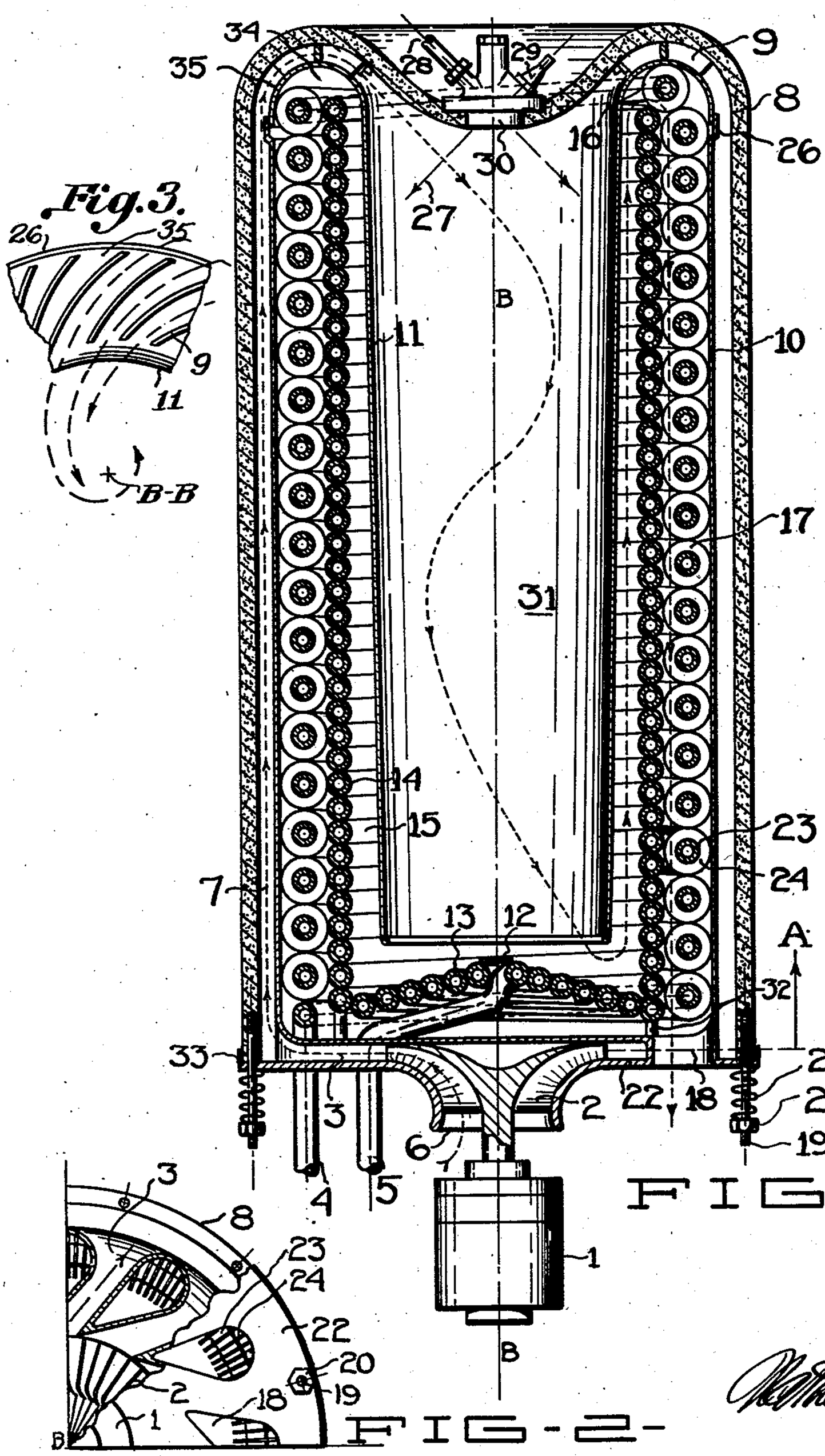

Fig. 3.

FIG-1-

FIG-2-

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FLUID HEATER

Nathan C. Price, Berkeley, Calif., assignor to Sirius Corporation, a corporation of California

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15 Claims. (Cl. 122—250)

The invention relates to fluid heaters and particularly to vapor generators such as steam boilers employing liquid or gaseous fuel as the heating medium.

An object of the invention is to provide a vapor generator which is particularly applicable for uses where lightness and compactness is of importance, such as in moving vehicles.

Other objects which are to be satisfied comprise, first, attainment of effective thermal counterflow between gases of combustion and the working fluid for high efficiency, second, ability to pre-heat the air fed to the combustion chamber in a manner which will reduce the amount of boiler insulation required and which will entail a minimum of structural material, third, ease of inspection of all heated surfaces and simplicity of construction, fourth, proper support of the heated surfaces to allow free thermal expansion and contraction eliminating harmful temperature stresses, fifth, ability to withstand explosions in the combustion chamber without structural damage, sixth, proportioning of much greater heat transfer area to the gases of combustion than to the working fluid thereby reducing the weight per vapor output ratio of the boiler and lessening heat storage, seventh, convergence of combustion gas flow passages in the direction of flow to establish substantially constant heat transfer from the inlet to the outlet of the boiler, and eighth, integration of the air supply system with the boiler.

The invention possesses other advantageous features which are evident in the illustrated form accompanying the following specifications.

Figure 1 is a section through the principal axis of one form of the invention showing a cylindrical vapor generator integrally combined with its air preheater, fuel injector, fuel igniter, and air supply pump in a manner providing advantageous relationship between the various elements.

Figure 2 is a quarter end view of Figure 1, revealing a fragment of section normal to the principal axis as designated by the letter A in Figure 1.

In Figure 3 is a fragmentary end view of some fins of Figure 1 for swirling air fed to the combustion chamber.

In Figure 1, a cylindrical cup shaped boiler casing encloses, in the order named, and consecutively toward the principal axis B, an air preheater duct 7, a cylindrical heat transferring envelope 10, a finned economizer helical coil 17, a close-wound superheater helical coil 14, a convergent combustion gas conducting space 15, a convergent cylindrical combustion chamber shroud 11, and a combustion chamber 31.

Feed liquid is supplied to the inlet 4 of the economizer coil 17, which comprises a tube 23 with numerous spaced circular fins 24 thermally bonded thereto.

At a region 34 the coil 17 is serially joined to the coil 14 and conducts evaporating working fluid thereto. Progressive superheating of the working fluid is accomplished in the coil 14 and in a serial close-wound coil 13, which is both conical and spiral. The conditioned working fluid is discharged from an outlet duct 5 to the consumer.

An appropriate liquid feed, air feed, fuel feed, and ignition regulation for this boiler is fully shown in my Patent No. 2,064,494 entitled "Control system."

The heating system illustrated in Figure 1 includes an electric motor 1 for rotating a centrifugal blower impeller 2. Supply air enters an inlet 6 and is discharged into a diffuser 3 for partial conversion of velocity head to pressure head.

The diffuser 3 is formed as a heat exchanging structure, which is integral with a series of flues 18. It also comprises a boiler end plate 22 to which the envelope 10 is mechanically joined.

The flues 18 are shaped and angularly positioned to form a tangential and divergent arrangement of diffuser vanes for high efficiency.

Furthermore a structurally sound boiler end plate is produced since the flues 18 act as stiffening webs. The blower impeller 2 is placed in an ideal position from the standpoints of directness of discharge and compactness.

The partially heated air leaving the diffuser 3 is directed along the air preheating duct 7 to extract more heat from the envelope 10, and finally passes at a relatively high temperature through some fins 9 into the combustion chamber 31.

The fins 9 are formed tangent to a circle about the boiler principal axis B in order to impart a twist to the incoming air as shown in Fig. 3.

The resultant rotating mass of air strikes a fuel spray envelope 27 issuing from a mechanical atomizing burner nozzle 30 of centrifugal type. Integral with the burner nozzle 30 are a fuel supply line 28, and an ignition plug 29 for lighting the fire.

Preferably the rotation af the fuel spray envelope is made opposite to that of the incoming air, to produce thorough mixing. However, the

moment of momentum of the air is greater than that of all the fuel droplets. A net rotation of the mixture results. Large droplets of fuel which burn slowly tend to become forced centrifugally against the hot shroud 11, where they rapidly vaporize and do not reach the boiler tubing.

The gases of combustion issue from the slightly conical chamber 31 and are deflected by a sealing disc 12 and the coil 13. Reversed direction flow along the space 15 results.

The space 15, bounded by the coil 14 and the shroud 11, is made convergent in direction of flow in order to maintain approximately the same rate of heat transfer throughout the entire length of the inner side of the coil 14.

When the gases of combustion reach the region 34, they are again reversed in direction of flow by a flange 35 of the shroud 11, and pass between the fins 24, the coil 14, and the envelope 10 to be finally discharged from the flues 18. A naturally high heat transfer exists between the liquid in the coil 17 and the inside of the tube 23 due to the thermal conductivity characteristics of liquids, while the gases of combustion on the other hand have intrinsically poor heat conductive capabilities.

Therefore, there is a considerable economy realized in material and space by utilizing means for obtaining of a much greater heating surface to the gases of combustion than to the economizer liquid. This is a primary function of the fins 24.

Furthermore, the fins serve as spacing means between adjacent loops of the coil 17, and between the coil 14 and the envelope 10.

Due to the free space constituting the air preheater duct 7, the heated inner portions of the boiler, such as the coil 14, the coil 17, and the envelope 10, are able to expand radially as temperature changes occur.

The combustion chamber shroud 11 is capable of expanding in all directions due to the space 15 surrounding it.

The various loops of the coil 13 are also free to expand due to the conical shape of the spiral.

For supporting the inner portions of the boiler axially, some spacing blocks 32 mechanically fix the periphery of the coil 13, to the boiler end plate 22. Some studs 19 threaded into the casing 8 serve with their nuts 20 and some coil springs 21 to hold a sealing slip-joint 33 between the casing 8 and the plate 22, at a minimum gap.

Accordingly the casing 8 produces axial pressure through the tangential fins 9 upon the flange 35 of the shroud 11. This flange bears upon the coil 17 and the coil 14 which in turn compress the periphery of the spiral coil 13.

The flange 35 is sealed to the envelope 10 by a slip-joint 26.

Therefore, as the temperature of the inner portion of the boiler increases relative to that of the casing 8, differential expansion along the principal axis B is permitted by the resultant compression of the springs 21.

Likewise in event of delayed ignition in the combustion chamber and a subsequent explosion, the springs 21 act as energy absorbing members to prevent rupture of the boiler casing. Also it is provided that under this condition the casing 8 may be moved so far axially from the plate 22, that direct pressure relief passages for gases are created through the slip-joint 26 and the slip-joint 33.

Figure 2 shows the construction of the blower end of the boiler as set forth in Figure 1. The same numeral designations apply in Figure 2. Above the broken line is revealed a section of Figure 1 taken at the letter A in Figure 1. Below the broken line an external end view is presented.

In Figures 1, 2, and 3 I have illustrated one form of fluid heater embodying my invention, but as set forth in the claims, it may be embodied in a plurality of forms.

I claim:

1. A boiler comprising a cylindrical envelope surrounding in substantially coaxial relationship and in the following sequence in the direction of the axis, an economizer tube helical coil having fins extending from the surface thereof, a smooth superheater tube helical coil, and a combustion chamber, said last named coil and said envelope defining a combustion gas flow path between said fins and parallel to said axis, means for supplying feed liquid to said economizer coil, and said superheater coil being connected to said economizer coil for heating vapor of said liquid.

2. In apparatus of the character described in claim 1, said fins abutting said superheater tube coil and thereby aligning said superheater coil with respect to said economizer coil.

3. In apparatus of the character described in claim 1, a cylindrical refractory shroud surrounded by said superheater coil and bounding said combustion chamber, an annular space lying between said shroud and said superheater coil for conducting gases of combustion from said chamber in counterflow to the boiler working fluid in said superheated coil, and said space converging in the direction of flow of said gases thereby maintaining the heat transfer to said superheater coil substantially constant along the tubular length of said superheater coil.

4. In apparatus of the character described in claim 1, said envelope being heat conductive, a cylindrical boiler casing surrounding said envelope, an annular duct lying between said casing and said envelope for preheating air for said combustion chamber, and means for forcing said air to flow in said duct counter to and in heat transferring relationship to the gases of combustion passing between said fins.

5. In apparatus of the character described in claim 1, said envelope being heat conductive, a cylindrical boiler casing surrounding said envelope, an annular duct lying between said casing and said envelope for preheating air for said combustion chamber, a blower for forcing said air along said duct counter to and in heat transferring relationship to the gases of combustion passing between said fins, and means for imparting a rotary motion about the boiler axis to said air thereby increasing the absorption of heat from said gases of combustion.

6. In apparatus of the character described in claim 1, said envelope being heat conductive, a cylindrical boiler casing surrounding said envelope, an annular duct lying between said casing and said envelope for preheating air for said combustion chamber, a compressor for forcing said air along said duct counter to and in heat transferring relationship to the gases of combustion passing between said fins, and a tangential flow passage connecting said duct to said combustion chamber for producing an air swirl about the boiler axis in said chamber.

7. In apparatus of the character described in claim 1, said envelope being heat conductive, an annular duct extending about said envelope for preheating air for said combustion chamber, a cylindrical boiler casing surrounding said duct,

a compressor for forcing said air along said duct in counterflow to and in heat transferring relationship to the gases of combustion passing between said fins, means for imparting a rotary motion about the boiler axis to said air thereby increasing the heat transmission from said gases to said air, and a tangential flow passage communicating between said duct and said chamber coincident in direction to the rotary motion in said duct.

8. A boiler tube comprising, a cylindrical boiler casing surrounding in substantially coaxial relationship and in sequence in the direction of the axis of said casing, an annular air preheating duct, a cylindrical heat conductive envelope, a finned economizer tube helical coil, a smooth superheater tube helical coil having closely wound loops for heating vapor of said liquid, and a cylindrical combustion chamber, means for forcing feed liquid into said economizer coil, a flow passage extending from said chamber along said superheater coil for heat contribution thereto, and an extension of said passage along said economizer coil and said envelope for heat contribution thereto.

9. In apparatus of the character described in claim 8, a centrifugal blower, a diffuser for said blower constructed of spaced plates, said plates having hollows, and means for conducting gases of combustion from said extension through the hollows in said plates.

10. A boiler comprising, a cylindrical boiler casing surrounding in substantially coaxial relationship and in sequence in the direction of the axis of said casing, an annular air preheating duct, a cylindrical heat conductive envelope, a boiler tube helical coil, and a combustion chamber, a pump for forcing feed liquid into said coil, a centrifugal combustion air impeller at one end of said duct, said impeller having an axis of rotation coincident with the axis of said casing, a diffuser for said impeller constructed of spaced plates arranged tangentially about the periphery of said impeller, said plates having hollows, a flow passage extending from said chamber along said coil for heat contribution thereto, and said passage being connected to said hollows.

11. A forced circulation boiler comprising a long once-through boiler tube having an inlet at one end thereof, an outlet at the other end thereof, and a change of state zone intermediate of said ends, said tube being directly exposed to flow of gases of combustion along substantially the entire length thereof from said inlet end to said outlet end, feed liquid alimentation means at said inlet, working vapor disposal means at said outlet, a cylindrical envelope encompassing said tube, a combustion chamber for producing said gases, said chamber communicating with the interior of said envelope, an air compressor connected to said chamber, said tube having a relatively constant internal diameter along its length from said inlet to said outlet, said liquid having a relatively high thermal conductivity, said vapor having a relatively low thermal conductivity, fin-like projections on the surface of said tube, and said projections being substantially proportionate to the thermal conductivity of the fluid being conveyed within said tube opposite thereto at each increment of the tube length.

12. A boiler comprising a first helical boiler tube having heat conductive fins on the external surface thereof, a flow passage between said fins, means for producing a relatively hot fluid, a pump for forcing said fluid along said passage, and a second helical boiler tube closely bounding said passage on one lateral side thereof.

13. A boiler comprising a boiler tube helical coil containing liquid and having a plurality of heat conductive fins extending from the external surface thereof, said fins being disposed transversely to the axis of said tube, a cylindrical envelope abutting said fins at one lateral side of the edges of said fins, a boiler tube system containing vapor and abutting said fins at the opposite lateral side of the edges of said fins, means for producing a relatively hot fluid, and a displacer for forcing said fluid between said fins.

14. A boiler comprising, a boiler casing, a helical economizer tube having heat conductive fins extending from the external surface thereof, a heat conductive envelope surrounding said economizer tube and abutting the edges of said fins at the outward side of said fins, a combustion chamber, an annular duct lying between said casing and said envelope for preheating combustion air for said chamber, a close-wound superheater tube helix encompassed by said economizer tube and abutting the edges of said fins at the inward side of said fins, an air compressor connected to said duct, and said combustion chamber being connected to the space between said fins.

15. A boiler comprising a cylindrical combustion chamber, a helical boiler tube system surrounding said chamber, an annular air duct surrounding said system, an imperforate cup-shaped casing surrounding said duct and having a conoidal end projecting into said chamber, an air compressor connected to one end of said duct, a disc-shaped passage connecting the opposite end of said duct to said chamber, a plurality of tangential vanes in said passage, and a fuel injection nozzle facing into said chamber at the center of said end.

NATHAN C. PRICE.