United States Patent

Rennolds

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[54] **ROTARY BOILERS**

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[52] **U.S. Cl.** 122/11

[51] **Int. Cl.** **F22b 5/00**

[58] **Field of Search** 122/10, 11, 12

[56] **References Cited**

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Primary Examiner—Kenneth W. Sprague
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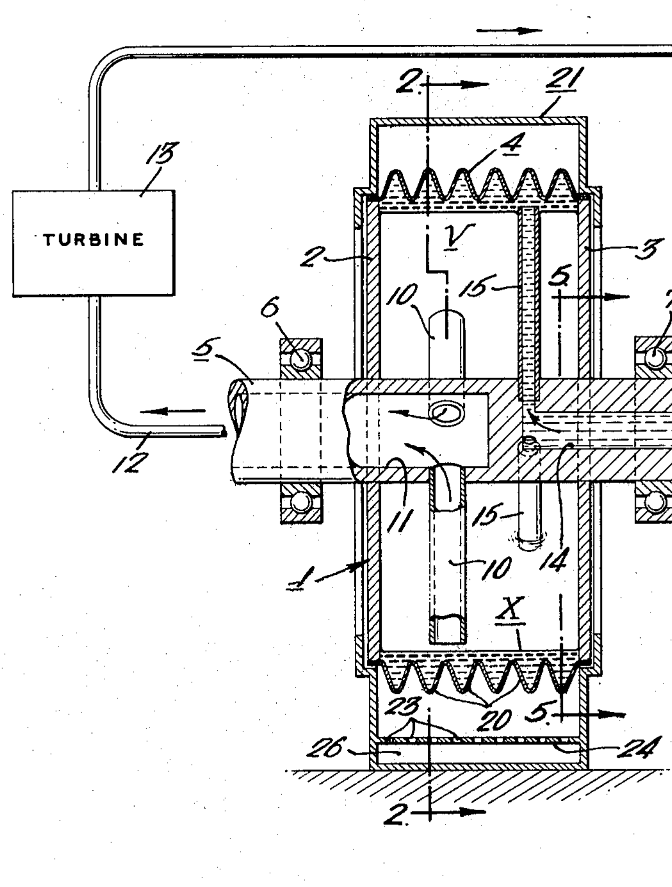
[57] **ABSTRACT**

A rotary boiler comprising a boiler chamber defined by axially spaced side walls and radially spaced outer peripheral wall. The boiler is rotated about its axis at a speed to maintain an annular body of organic liquid distributed circumferentially about the inner surface of the peripheral boiler wall with a cylindrical liquid/vapor interface disposed at a predetermined radius from the rotation axis. Combustion means is provided outwardly adjacent the boiler peripheral wall to heat and vaporize the liquid at high boiling heat fluxes greater than obtainable at ambient gravity. The boiler peripheral wall is configurated, as by flutes or corrugations, in the circumferential direction to provide transversely thereof in the axial direction a total length of wall heat conduction surface to the liquid that is substantially greater than the linear axial spacing of the boiler side walls at the liquid/vapor interface. The greater heat conduction surface of the peripheral wall reduces the heat flux at the wall and the temperature difference between the wall and the liquid/vapor interface to an extent that a compact boiler can be operated at high overall thermal flux with minimal decomposition of the boiler fluid.

6 Claims, 11 Drawing Figures



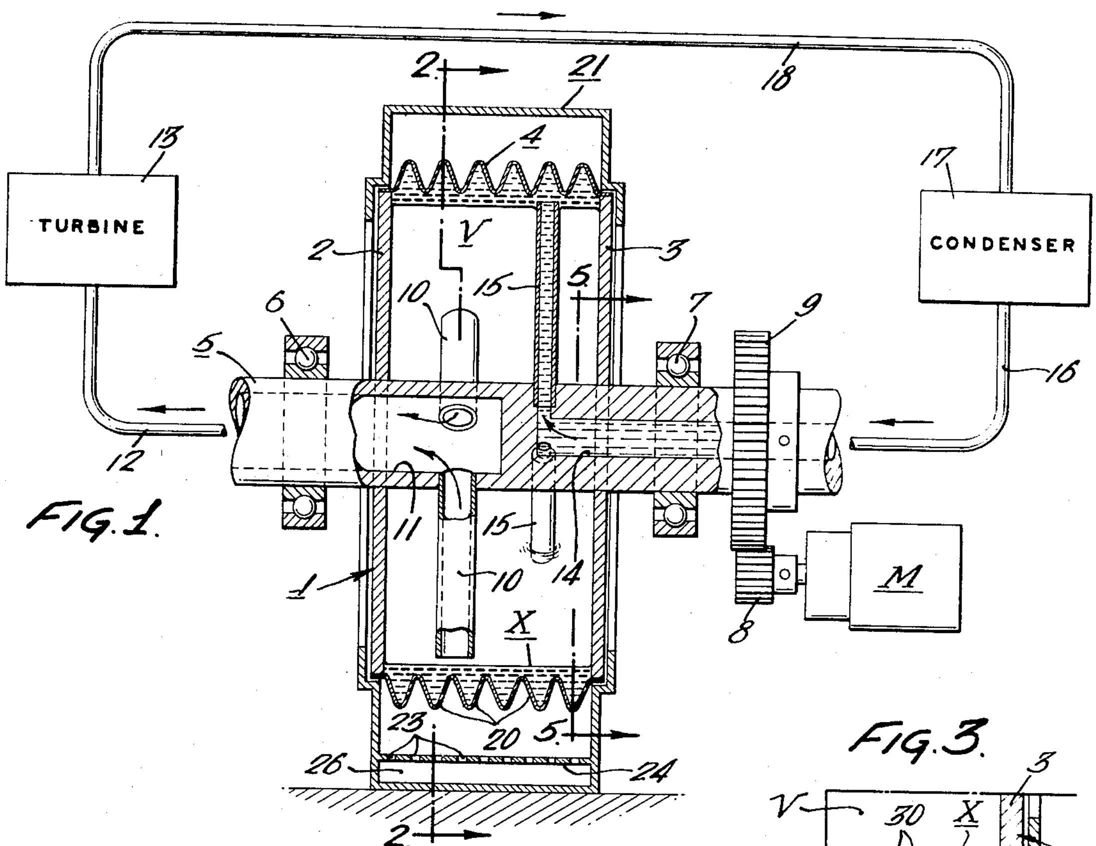


FIG. 1.

FIG. 3.

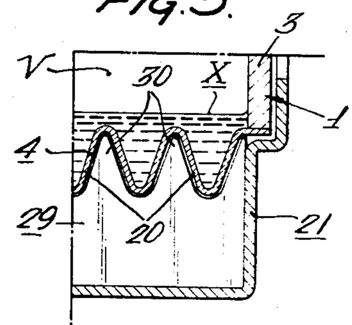


FIG. 2.

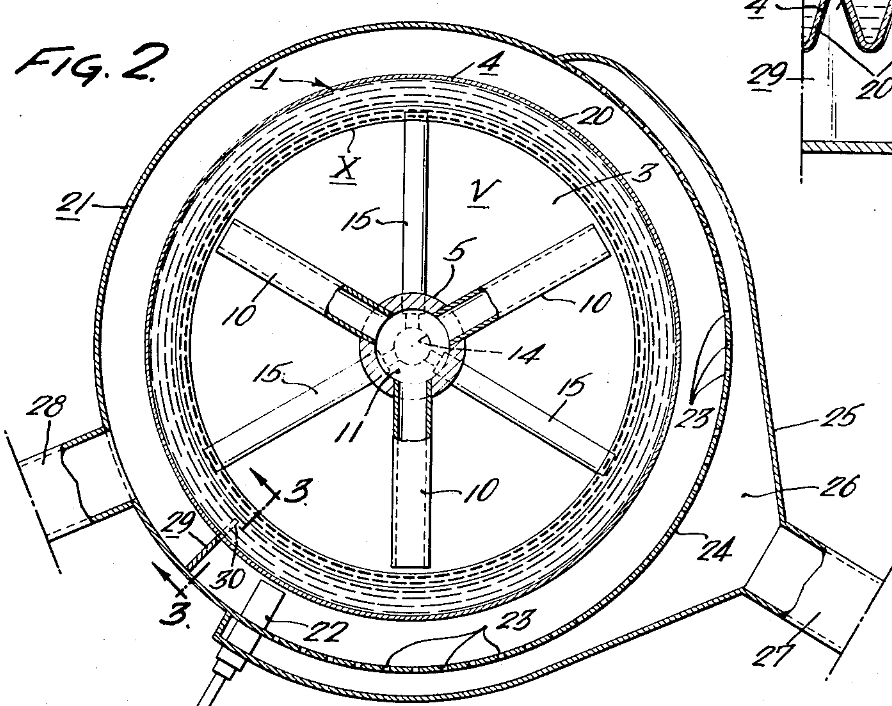


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FIG. 4.

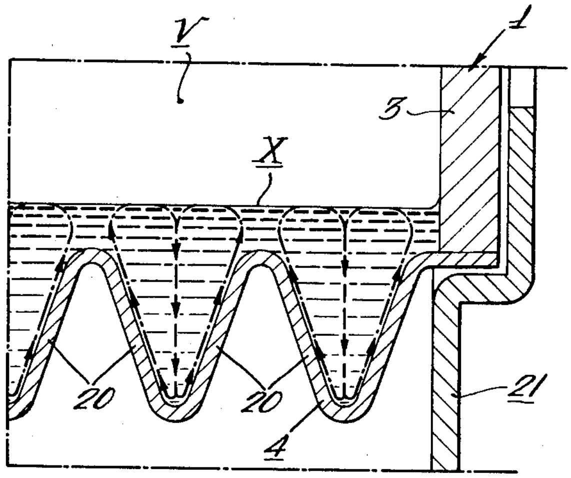
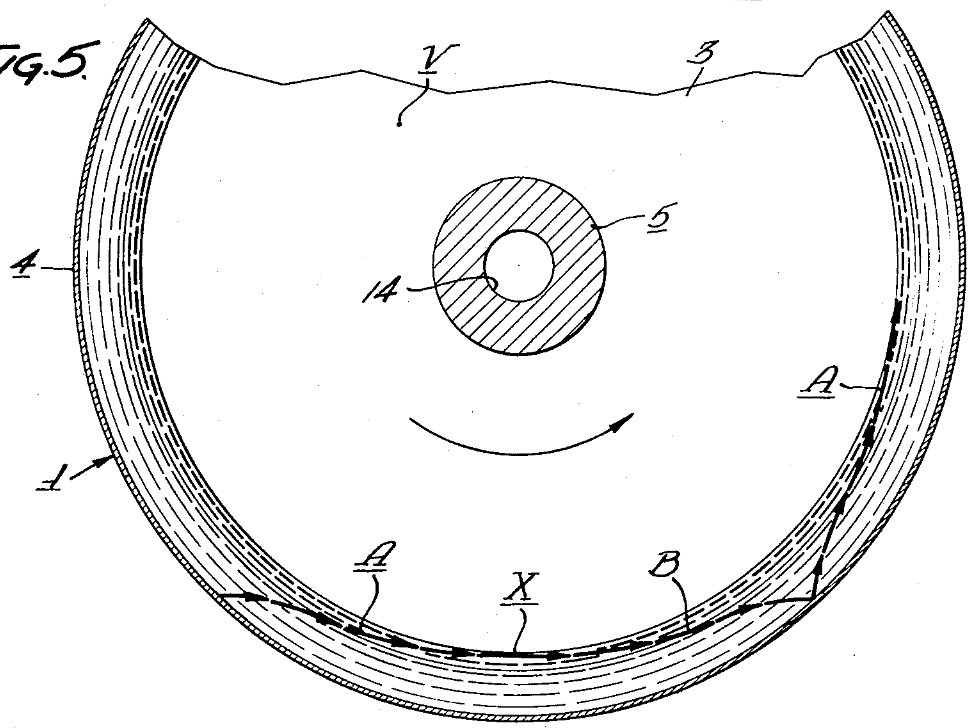


FIG. 5.



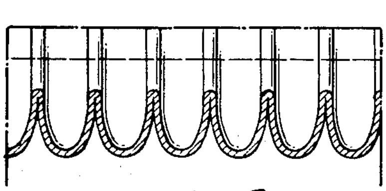


FIG. 8.

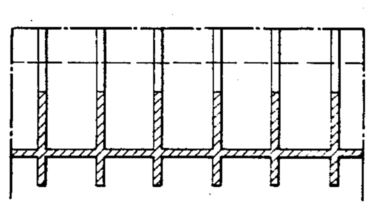


FIG. 9.

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FIG. 6.

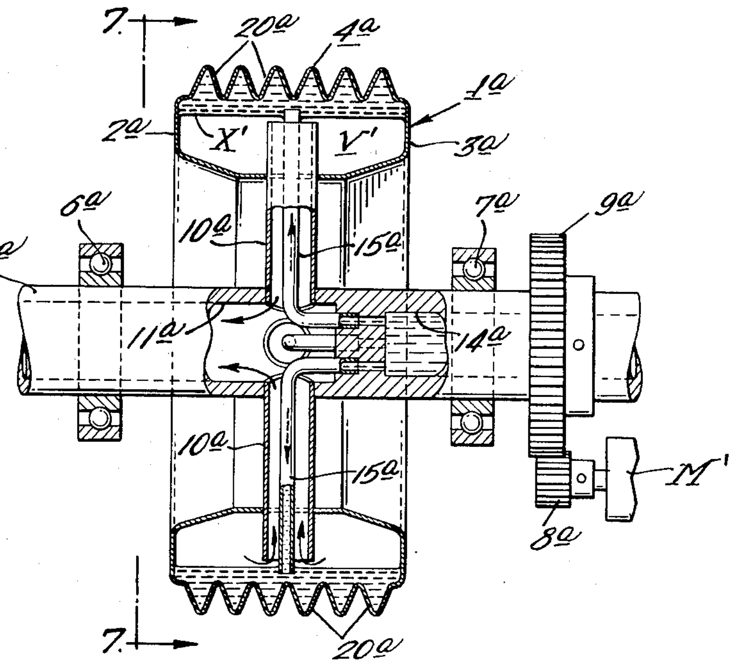


FIG. 7.

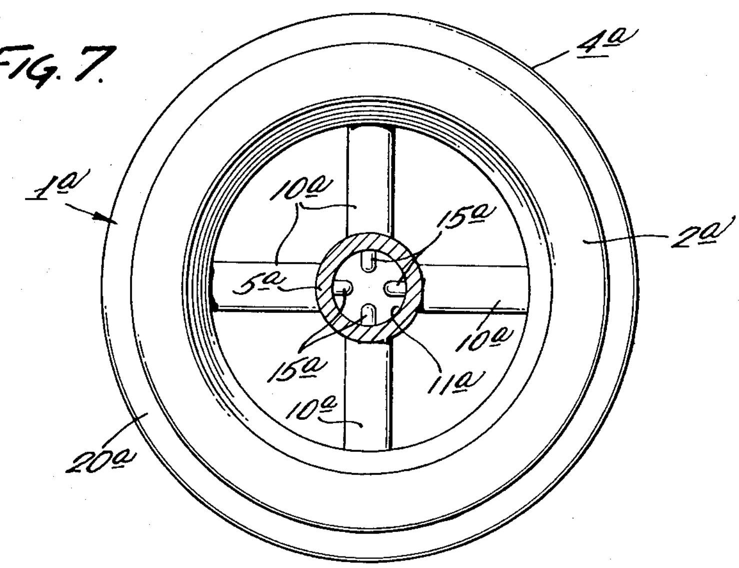


FIG. 10.

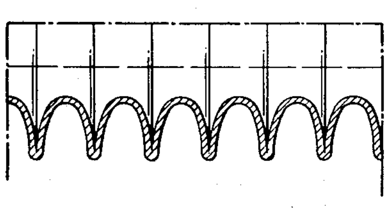
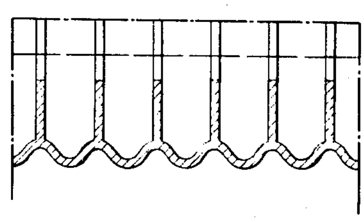


FIG. 11.



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ROTARY BOILERS

The present invention relates to rotary boilers, and more particularly to rotary boilers of novel construction particularly adapted for use in closed-Rankine-cycle engines.

Rotary boilers are known in the art of vapor generation and have been demonstrated to provide a number of advantages over conventional boilers. For example, the high centrifugal acceleration in such a boiler produces a sharp stable interface between the liquid and vapor during boiling. Such a boiler produces a high quality vapor with steady flow of both vapor and liquid and the boiler operates independent of the ambient gravity field and orientation. Also, the high rotational speeds customarily employed in rotary boilers permit heat fluxes well above the peak boiling level for ambient gravity.

A closed-Rankine-cycle engine using external combustion as a source of heat is capable of providing an excellent low-pollution replacement for conventional internal combustion engines customarily used in automotive vehicles. A practical closed-Rankine-cycle engine for such use must be small and compact and, therefore, necessarily requires a vaporizer or boiler that is also compact and is operable with high molecular weight organic power fluids that can be vaporized with little or no decomposition of the organic fluid.

It has been determined that rotary boilers using high molecular weight organic power fluids at high rotational speed can be operated effectively to provide the high heat flux at the liquid/vapor interface necessary for the desired structural compactness of the rotary boiler, for example, as described in the copending application of William A. Doerner, Ser. No. 12,296, filed Feb. 18, 1970, now U.S. Pat. No. 3,590,786.

However, in rotary boilers having a flat cylindrical peripheral boiler heat conducting wall of sufficiently short axial length to provide a small compact practical Rankine engine, a high heat flux is produced at the boiler wall and the temperature difference between the inner surface of the boiler wall and the boiler liquid/vapor interface is so great that it would be necessary to operate the engine either at a very significant reduction in the overall thermal efficiency of the engine or at an unacceptable high rate of decomposition of the organic boiler power fluid.

Moreover, since the maximum rate of decomposition of the organic power fluid must be very low for a practical Rankine engine and thereby determine the maximum temperature of the boiler peripheral wall, a large temperature difference between the boiler wall and the liquid/vapor interface would lead to a lower liquid/vapor interface temperature which, for a fixed condenser temperature, would result in a substantial reduction in the thermodynamic efficiency of the overall engine.

It has been discovered that the foregoing difficulties encountered in rotary boilers can be overcome by providing a rotary boiler of relatively short, compact axial length defined by axially spaced side walls and a circumferentially extending outer peripheral wall that is suitably configurated, such as fluted or corrugated, in the direction circumferentially of the boiler to provide in the axial direction transversely of said peripheral wall a combustion heat conduction surface of substan-

tially greater extent or length than the linear axial spacing of the boiler end walls at the liquid/vapor interface.

In such a rotary boiler operated at rotational speeds to maintain an annular body of high molecular organic boiler liquid continuously about the inner surface of the peripheral wall with a cylindrical liquid/vapor interface at a radius from the rotational axis that provides boiling heat fluxes in excess of those obtainable at ambient gravity, the increased extent or length of the boiler peripheral wall surface provides a greatly reduced heat flux at the wall that is substantially less than the high heat flux at the liquid/vapor interface, thereby greatly reducing the temperature difference between the peripheral wall and the liquid/vapor interface while still maintaining the high boiling heat flux at said liquid/vapor interface that is required for a compact boiler while at the same time providing a very low rate of decomposition of the organic boiler fluid.

With the foregoing in mind, an object of the present invention is to provide a rotary boiler of novel design and construction useful for vaporizing liquids, including water and refrigerant liquids, and particularly suited for use in closed-Rankine-cycle engines.

Another object of the invention is to provide a rotary boiler of novel design and construction that is of relatively small, compact size and can be operated using high molecular weight organic power fluid to provide high boiling heat fluxes at the liquid/vapor interface with little or no decomposition of the organic power fluid.

A further object of the invention is to provide a rotary boiler as set forth which is operable at high heat flux at the liquid/vapor interface and at a substantially lower heat flux at the peripheral boiler wall so that the difference between the temperature at the boiler wall and the temperature at the liquid/vapor interface is sufficiently small to enable the rotary boiler to be operated in a closed-Rankine-cycle engine at maximum overall thermal efficiency of the engine.

These and other objects of the invention and the various features and details of the construction and operation thereof are hereinafter set forth and shown in the accompanying drawings, in which:

FIG. 1 is a sectional view taken diametrically through a rotary boiler and stationary combustion chamber embodying the present invention showing the same schematically in a closed-Rankine-cycle power generation system including a turbine and a condenser;

FIG. 2 is a sectional view taken on line 2—2, FIG. 1;

FIG. 3 is a fragmentary view on line 3—3, FIG. 2;

FIG. 4 is an enlarged fragmentary transverse sectional view similar to FIG. 3 schematically illustrating the radial component of convection flow of liquid in the boiler;

FIG. 5 is an enlarged sectional view on line 5—5, FIG. 1 schematically illustrating the tangential or spiral components of convection flow of liquid in the boiler;

FIG. 6 is a view generally similar to FIG. 1 showing a modified construction of a rotary boiler embodying the present invention;

FIG. 7 is a sectional view taken on line 7—7, FIG. 6, and

FIGS. 8,9, 10 and 11, respectively, are enlarged fragmentary transverse sectional views showing modifications in design and construction of the outer peripheral wall of the rotary boiler.

Referring now to the drawings, and more particularly to FIGS. 1 and 2 thereof, one embodiment of rotary boiler constructed according to the present invention comprises a generally cylindrical casing 1 having axially spaced side walls 2 and 3, respectively, and a continuous circumferentially extending outer peripheral wall 4 of predetermined cross-sectional configuration and dimensions as hereinafter more particularly described. Fixedly secured to and extending coaxially through the casing side walls 2 and 3 is a shaft member 5 by means of which the boiler casing 1 is rotatably mounted in bearings 6 and 7. The boiler may be rotationally driven at the desired speed by means of an electric motor M driving a gear 8 which in turn drives a gear 9 mounted on the shaft 5.

The space enclosed within the circumferential wall 4 and side walls 2 and 3 of the boiler defines a vapor chamber V within the rotating boiler casing 1. The chamber V is in communication through a plurality of vapor tubes 10 with an axial passage 11 in the shaft 5 so that the vapor generated in the boiler and collecting in the chamber V is discharged from the rotating boiler through the vapor tubes 10, said shaft passage 11 and a conduit 12, for example, to a suitable expander such as a turbine 13. The vapor tubes 10 function to transfer rotational energy in the vapors back to the linear exit system as the vapors leave the boiler through the shaft 5, and the tubes 10 are disposed in equally spaced relation circumferentially around the boiler to insure rotational balance when driven by the motor M.

Liquid is admitted to the boiler at a controlled rate equal to the rate of vaporization of the liquid. In the illustrated embodiment the liquid admitted to the boiler is in the form of liquid condensate, fed through an axial passage 14 in the shaft 5 and a plurality of feed tubes 15 extending radially from passage 14 to a point below the surface level of the boiler liquid. Preferably, the feed tubes 15 are thermally insulated or fabricated of suitable insulating material since the liquid pressure in said tubes 15 increases with their radius and is therefore relatively lower adjacent the rotation axis so that excessive heating of the lower pressure liquid may cause vapor binding within the tubes and interference with pumping of the liquid.

The liquid condensate is supplied to the shaft passage 14 by a pipe 16 from a condenser 17 having its inlet connected by a conduit 18 to the exhaust of the turbine 13. As in the case of the vapor tubes 10, the feed tubes 15 are equally spaced circumferentially around the boiler for rotational balance. The radial vapor tubes 10 and feed tubes 15 are desirable in a boiler of the present type to control radial flow of the liquid and vapor fluids for proper and efficient operation of the boiler for the reasons set forth in the aforesaid copending application of William A. Doerner, Ser. No. 12,296, filed Feb. 18, 1970, now U.S. Pat. No. 3,590,786. However, means other than the tubes 10 and 15, such as baffles, to insure rotation of the boiler liquid with the boiler, can be employed.

The rotary boiler is driven by the motor M at a predetermined speed of rotation calculated to create the centrifugal force necessary to dispose and maintain the selected boiler liquid uniformly distributed circumferentially about and in contact with the inner surface of the outer peripheral wall 4 of the boiler, with a liquid/vapor interface, designated x in FIG. 1, that is

highly stable and is essentially cylindrical and concentric with the axis of rotation of the boiler. Essentially, the liquid/vapor interface x is disposed at a predetermined radius from the rotation axis of the boiler to provide high boiling heat fluxes in excess of those obtainable at ambient gravity and also to provide the desired boiler (vapor) pressure correlated to the radial length of the liquid leg in the feed tubes 15.

In order to provide a rotary boiler of sufficiently small compact size for practical use in a closed-Rankine-cycle engine, the diameter of the outer peripheral wall 4 of the boiler and the axial spacing of the end walls 2 and 3 must be as small as possible and at the same time provide at the speed of rotation a liquid/vapor interface x of sufficient axial length and radius to produce the high boiling heat fluxes and desired boiler (vapor) pressure previously described.

However, there has not been available heretofore an efficient rotary boiler for use with high molecular weight organic power fluids in closed-Rankine-cycle engines because, as previously described, in the usual rotary boiler construction having the customary flat cylindrical peripheral wall of the same linear axial length as the liquid/vapor interface, the heat flux at the peripheral wall is high and the temperature difference between the said wall and the liquid/vapor interface is so great that the engine can only be operated either at very low overall thermal efficiency or at a very high rate of decomposition of the organic boiler power fluid.

According to the present invention it has been discovered that by forming or constructing the boiler peripheral wall 4 to provide the axial direction transversely of the wall 4 a combustion heat conduction surface to the liquid having a total length substantially greater than the linear axial spacing of the boiler side walls 2 and 3 at the liquid/vapor interface a substantially lower heat flux is produced at the boiler wall 4 which results in a significantly large decrease in the temperature difference between the boiler wall 4 and the liquid/vapor interface. Unexpectedly, this temperature difference is significantly less than would be predicted merely from the increase in the area of the fluted or corrugated peripheral boiler wall 4 over the area of a similar boiler with a conventional flat cylindrical peripheral wall. By reason of this construction with its attendant results the required high heat flux can be maintained at the liquid/vapor interface and it is possible to operate the boiler at maximum overall engine efficiency with very little or no decomposition of the organic boiler fluid.

The required increase or extended axial length of combuation heat conduction surface of the peripheral boiler wall can be provided by forming or constructing the peripheral wall 4 in a manner to include circumferentially therein, for example, a plurality of parallel continuous flutes or corrugations 20, as shown in FIG. 1. The wall 4 is fabricated of any suitable heat conductive metal such as, for example, steel, copper, aluminum and the like, and the number of the flutes or corrugations 20 and the configuration and dimensions thereof are selected and predetermined to provide a total axial direction length of heat conductive peripheral wall surface with respect to the linear axial length of the liquid/vapor interface sufficient to enable the boiler to be operated at maximum overall thermal efficiency of the closed-Rankine-cycle engine with minimal decomposition of the organic power fluid.

More particularly, it has been determined that the total axial direction length of the peripheral wall heat comductive surface to liquid provided by the present invention should be at least one and one-half times the linear axial spacing of the boiler side wall portions 2 and 3 at the liquid/vapor interface (i.e., the linear axial length of the interface x in FIG. 1) and preferably, for best results, should be in the range of from about 3 to about 5 times the linear axial spacing of the boiler end walls 2 and 3 at the interface x or the axial length of said interface. These specifications relate to "smooth" inner surfaces of the wall 4 and the results are obtainable apart from the additional benefits that can be obtainable by increasing surface roughness, that is, the "-boiling chip effects", which can be achieved by methods known in the art such as sand blasting the boiler inner wall surface or by bonding metal powder or porous substances thereto.

The annular body of liquid in the boiler may be heated to the required boiling temperature to vaporize the same, for example, by the combustion of a suitable fuel-air mixture in a stationary combustion box 21 that circumscribes the rotatable boiling casing 1. Fuel for combustion is discharged into said combustion box 21 from a nozzle 22 at the required rate and pressure, and air for mixture with the fuel is discharged into the combustion box through a plurality of ports 23 in the peripheral wall 24. A hood structure 25 defines a plenum chamber 26 into which the air is supplied through a duct 27 at the pressure and volume required for efficient combustion of the fuel to heat the liquid in the boiler casing to the desired temperature. The residual combustion gases are discharged through an exhaust duct 28 and a stationary transverse baffle 29 having projecting portions 30 for complementary interfitting cooperation with the flutes or corrugations 20 of the boiler peripheral wall 4 is mounted intermediate the fuel nozzle 22 and outlet duct 28 to control recirculation of the combustion gases.

For a typical example, a rotary boiler constructed in accordance with the invention comprises a metal peripheral boiler wall 4 of 0.031 inch thickness having circumferential flutes or corrugations 20 therein. The inner and outer diameters of the inner corrugated surface are 6 inches and 6 15/16 inches, respectively, and the pitch or distance in a direction parallel to the axis of symmetry between similar points on adjacent corrugations is 0.335 inch. The radii at the peaks of the several corrugations 20 are 0.031 inch inside and 0.062 inch outside, respectively, and the linear axial spacing of the boiler side wall portions 2 and 3 at the liquid/vapor interface is 1.34 inches.

In the boiler described, the peripheral wall 4 having the flutes or corrugations 20 provides in the axial direction of the boiler a total surface length of the peripheral wall 4 that is 3.16 times the linear axial spacing of the boiler side wall portions.

In operation, the described rotary boiler provides a substantially low heat flux at the peripheral wall 4 and produces very much smaller temperature differences between the wall 4 and the liquid/vapor interface with high boiling heat fluxes at said interface as compared to a similar rotary boiler having a flat or axially plane peripheral wall surface. For example, in operation of the described boiler at 4500 r.p.m. at a boiler pressure of 55 psia and heated at a rate providing a heat flux at the boiler wall 4 of 47,200 Btu/hr ft^2, the average temperature difference between wall 4 and liquid/vapor interface was 58° F. A similar flat peripheral wall boiler with the same linear axial spacing of the boiler side wall portions would have 1/3.16 of the boiler area and would therefore require a heat flux of 149,000 Btu/hr ft^2 to provide the same total heat input to the fluid.

By comparison, in a similar boiler having a flat peripheral wall operated under the same conditions but with a heat flux at the boiler wall of 149,000 Btu/hr ft^2, the temperature difference between the wall and liquid vapor interface was 83° F. Moreover, the same flat peripheral wall boiler operated under the same conditions but heated at a much lower rate to provide a heat flux at the peripheral boiler wall of 47,200 **Btu/hr ft^2** still produced a temperature difference of as much as **75°** F. between the peripheral wall and the liquid/vapor interface.

The results obtained in the foregoing and additional operations of contoured wall boilers of the invention in comparison with similar flat wall boilers are set forth in the following Table I:

TABLE I

Boiler operated at **4500** r.p.m. in the following examples.

Boiler Wall Type	Boiler Pressure psia	Heat Flux, Btu/hr ft^2 Equal Length Flat Wall	Heat Flux, Btu/hr ft^2 Actual Boiler Wall	Average Temp. Diff. °F.
Boiler liquid = Bistrifluoromethylbenzyl alcohol				
Corrugated	55	149,000	47,200	58
Flat	55	149,000	149,000	83
Flat	55	47,200	47,200	75
Boiler liquid = Benzene				
Corrugated	14.7	368,000	116,500	66
Flat	14.7	368,000	368,000	111
Flat	14.7	116,500	116,500	80
Corrugated	14.7	272,000	86,000	66
Flat	14.7	272,000	272,000	100
Flat	14.7	86,100	86,100	77

The unexpected benefits and advantages provided by the present invention are believed to result from a novel scrubbing interaction between the particles of the boiler liquid and the circumferentially extending annular surfaces provided by the flutes or corrugations of the peripheral boiler wall 4. Thus, as schematically illustrated in FIGS. 4 and 5 of the drawings, the particles of boiler liquid within the rotating boiler travel in paths or trajectories comprising both radial and tangential directions at different accelerations and speeds as indicated by the arrows in said FIGS. r4 and 5.

For example, it is believed that a liquid particle moving inwardly from the peripheral wall 4 toward the liquid/vapor interface will be accelerated and travel in the direction of boiler rotation at a speed greater than the speed of the boiler as indicated by the arrow A in FIG. 5, whereas a liquid particle moving away from the liquid/vapor interface toward the peripheral wall 4 will be decelerated from the greater speed of the liquid at the liquid/vapor interface to substantially the speed of the peripheral wall near its outer radius as indicated by the arrow B.

As the result of this in and out circumferential movement of the liquid particles with the accompanying changes in their speed of travel as accelerated and decelerated within the body of boiler liquid, it is believed that the individual liquid particles, for a boiler operating at high speed, will make a number of revolutions within the rotating body of liquid in the boiler before they arrive at the liquid/vapor interface and are converted into vapor at the desired boiler (vapor) pressure. By this action the liquid particles are retained in scrubbing interaction with the inner surface of the peripheral wall **4** a period of time to insure maximum heat convection from the wall **4** to the boiler liquid.

Still other benefits and advantages provided by the present invention arise from the reduced thickness of the corrugated boiler wall. For the same boiler wall stress, the corrugated boiler wall is much thinner than a flat wall boiler of equal axial length providing the same heat flux at the liquid/vapor interface. The thinner metal wall of the corrugated boiler, operating at a fraction of the peripheral wall heat flux of a flat wall boiler, requires a greatly reduced thermal gradient through the metal wall to conduct the necessary heat flux through the wall. The difference in thermal gradient between a corrugated and flat wall boiler is still greater for the case where the flat wall boiler is provided with fins on its external periphery to promote heat transfer from the combustion heating gases. The reduction in thermal gradient in the boiler wall for a corrugated boiler reduces the average wall temperature and thus makes possible the use of cheap alloys. That is, expensive alloys normally used in high temperature Rankine cycle engine boilers are not required. Furthermore, the lower temperature of the external surface of the corrugated boiler wall significantly increases heat transfer from the hot combustion gases due to the greater temperature difference between the hot gases and the boiler wall thereby improving burner efficiency. A further advantage of the thinner metal wall of the configurated boiler is its faster response to increased heat input.

A modified construction of a rotary boiler embodying the present invention is shown in FIGS. **6** and **7** of the drawings. Referring to FIGS. **6** and **7**, the rotary boiler shown is a wheel-like structure comprising an annular casing **1***a* having axially spaced side walls **2***a* and **3***a*, respectively, and a continuous circumferentially extending outer peripheral wall **4***a* provided with circumferentially extending parallel continuous flutes or corrugations **20***a* therein constructed and arranged as previously described. The annular casing **1***a* is supported concentrically from a shaft **5***a* by a plurality of vapor tubes **10***a*. The shaft **5***a* is rotatably mounted in bearings **6***a* and **7***a* and the boiler may be rotationally driven at the desired speed by means of an electric motor M′ driving a gear **8***a* which in turn drives a gear **9***a* mounted on the shaft **5***a*.

The space within the peripheral wall **4***a* and side walls **2***a* and **3***a* of the casing **1***a* defines a vapor chamber V′ that is in communication through the vapor tubes **10***a* with an axial passage **11***a* in the shaft **5***a* so that vapor generated in the boiler and collecting in the chamber V′ is discharged inwardly through the vapor tubes **10***a* and shaft passage **11***a* to a suitable expander as previously described.

Liquid is admitted to the boiler, for example, in the form of liquid condensate from an axial passage **14***a* in the shaft **5***a* by means of a plurality of feed tubes **15***a* that extend radially outward within the vapor tubes **10***a* to a point below the surface level of the boiler liquid. The vapor tubes **10***a* and feed tubes **15***a* are equally spaced circumferentially with respect to the shaft **5***a* and boiler casing **1***a* to impart rotational balance to the boiler.

The rotary boiler is driven by the motor M′ at a predetermined speed of rotation to dispose and maintain the selected boiler liquid uniformly distributed circumferentially about the inner surface of the peripheral wall **4***a* of the boiler with a cylindrical liquid/vapor interface designated *x*′ in FIG. **6**. In operation of the boiler in the manner previously described with reference to FIGS. **1–5** of the drawings, the flutes or corrugations **20***a* in the boiler peripheral wall **4***a* provide a substantially low heat flux at the peripheral wall **4***a* and very much smaller temperature differences between said wall **4***a* and the liquid/vapor interface *x*′ with high boiling heat flux at said interface as compared to a similar rotary boiler having a flat or axial plane peripheral wall surface.

The design and construction of the boiler peripheral wall is not limited to the particular configuration and arrangement provided by the flutes or corrugations **20** and **20***a* in the walls **4** and **4***a* shown in FIGS. **1** and **6**, respectively, of the drawings. Various other configurations and constructions may be employed, for example, as shown in FIGS. **8**, **9**, **10** and **11**, the arrangements of FIGS. **8** and **10** being preferred over FIGS. **9** and **11**, so long as the peripheral wall configuration employed provides the increased or extended total axial length of heat conduction to liquid surface of the wall **4***a* to produce the desired low heat flux at the peripheral wall and the small temperature difference between the wall and liquid/vapor interface required for operation of the boiler at the desired high boiling heat flux at the liquid/vapor interface with minimal decomposition of the boiler fluid.

From the foregoing, it will be apparent that the present invention provides a rotary boiler that may be constructed in relatively small, compact size having high strength characteristics. Such a boiler is especially suited for use with high molecular weight organic power fluids and provides high heat fluxes at the liquid/vapor interface with minimal decomposition of the power fluid and substantially lower heat fluxes at the peripheral boiler wall. Thus, the resulting temperature difference between the boiler wall and the liquid/vapor interface is sufficiently small to enable operation of the rotary boiler in a closed-Rankine-cycle engine at maximum overall thermal efficiency of the engine with fast response to increased heat input.

While certain embodiments of the present invention have been illustrated and described, it is not intended to limit the invention to such disclosures and changes and modifications may be made and incorporated as desired within the scope of the claims.

I Claim:

1. A rotary boiler comprising,
   - a generally cylindrical structure having axially spaced apart side wall portions interconnected by a continuous circumferentially extending peripheral wall defining a boiler chamber,

means to admit liquid to the boiler chamber,

means to rotationally drive the boiler at a predetermined speed to dispose and maintain a body of the liquid continuously about the inner surface of said peripheral wall with a cylindrical liquid/vapor interface of predetermined radius from the rotation axis providing high boiling heat fluxes in excess of those obtainable at ambient gravity,

combustion means adjacent the peripheral wall of the boiler operable to heat and vaporize the liquid therein,

and means for withdrawing the vapor from the boiler,

the linear axial spacing of the boiler side walls at said liquid/vapor interface and at said peripheral wall being approximately the same and said peripheral wall being contoured transversely and circumferentially of the boiler to provide a combustion heat conduction peripheral wall having inner and outer surfaces respectively confronting the liquid and combustion means having a total length in the axial direction substantially greater than the linear axial spacing of the boiler side wall portions, thereby providing at the peripheral wall a heat flux substantially less than the heat flux at the liquid/vapor interface and a substantially small temperature difference between the wall and the liquid/vapor interface while still maintaining high boiling heat flux at said liquid/vapor interface.

2. A rotary boiler as claimed in claim 1,

wherein the total length of the contoured combustion heat conduction peripheral wall surface in axial direction is at least one and one-half times the linear axial spacing of the boiler side wall portions at the liquid/vapor interface.

3. A rotary boiler as claimed in claim 1,

wherein the total length of the contoured combustion heat conduction peripheral wall surface in the axial direction is within the range of from about three to about five times the linear axial spacing of the boiler side wall portions at the liquid/vapor interface.

4. A rotary boiler as claimed in claim 1,

wherein the boiler peripheral wall is contoured to provide transversely thereof a plurality of continuous circumferentially extending annular surfaces in contact with the boiler liquid operable to entrain particles of said liquid in paths of movement having both radial and circumferential directional components at different accelerations and speeds relative to the boiler rotation whereby the liquid particles are retained in scrubbing interaction with said annular surfaces a period of time to insure maximum heat conduction from the boiler wall to the boiler liquid.

5. A rotary boiler as claimed in claim 1,

wherein the contoured peripheral wall comprises at least one pair of continuous circumferentially extending confronting annular surface portions disposed at outwardly converging acute angles to the rotational axis of the boiler.

6. A rotary boiler as claimed in claim 4,

wherein the annular surfaces comprise at least one pair of said surfaces disposed in confronting outwardly converging relation at acute angles to the rotational axis of the boiler.

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