

[54] VAPOR GENERATOR

[75] Inventor: Ernest R. Earnest, Hobe Sound, Fla.

[73] Assignee: The Hydrogen Corporation, Palm Beach, Fla.

[22] Filed: Feb. 11, 1974

[21] Appl. No.: 441,666

[52] U.S. Cl. 122/250 R, 122/483, 165/163

[51] Int. Cl. F22b 27/08

[58] Field of Search 122/247, 248, 249, 250, 122/483; 165/163

[56] References Cited

UNITED STATES PATENTS

1,647,960 11/1927 D'Espujols 122/250

1,738,086	12/1929	Wadsworth	122/250 X
1,746,158	2/1930	Laffler	122/250 X
1,800,306	4/1931	Laffler	122/483 X
2,035,908	3/1936	Michel	122/250
2,227,293	12/1940	Bobo	122/250
3,267,909	8/1966	McClanahan	122/250

Primary Examiner—Kenneth W. Sprague

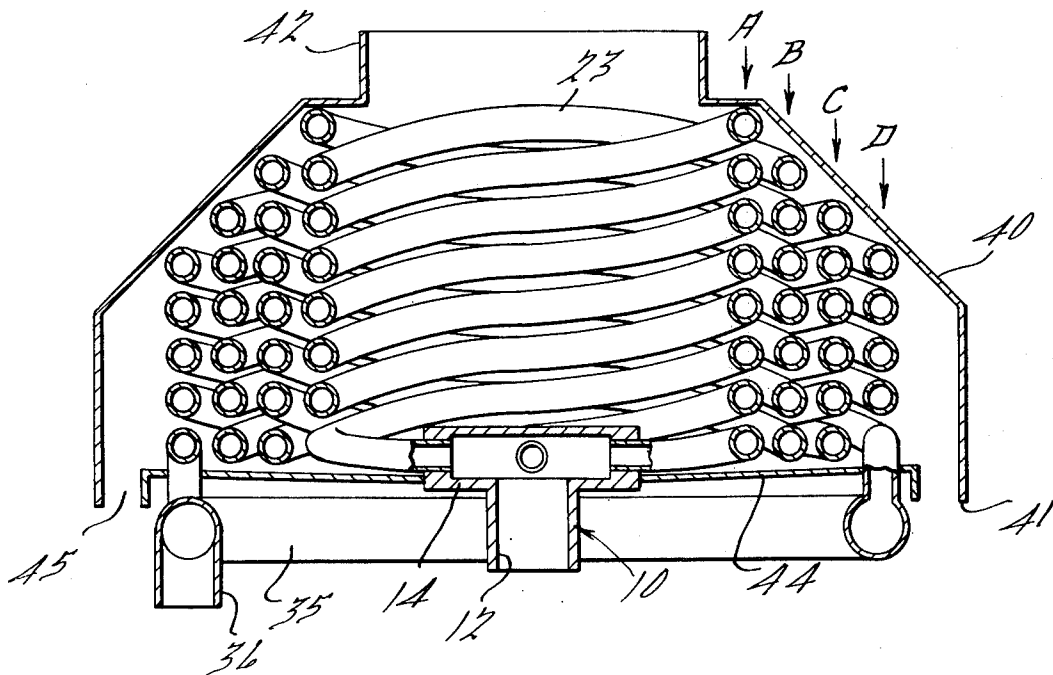
Attorney, Agent, or Firm—Harness, Dickey & Pierce

[57]

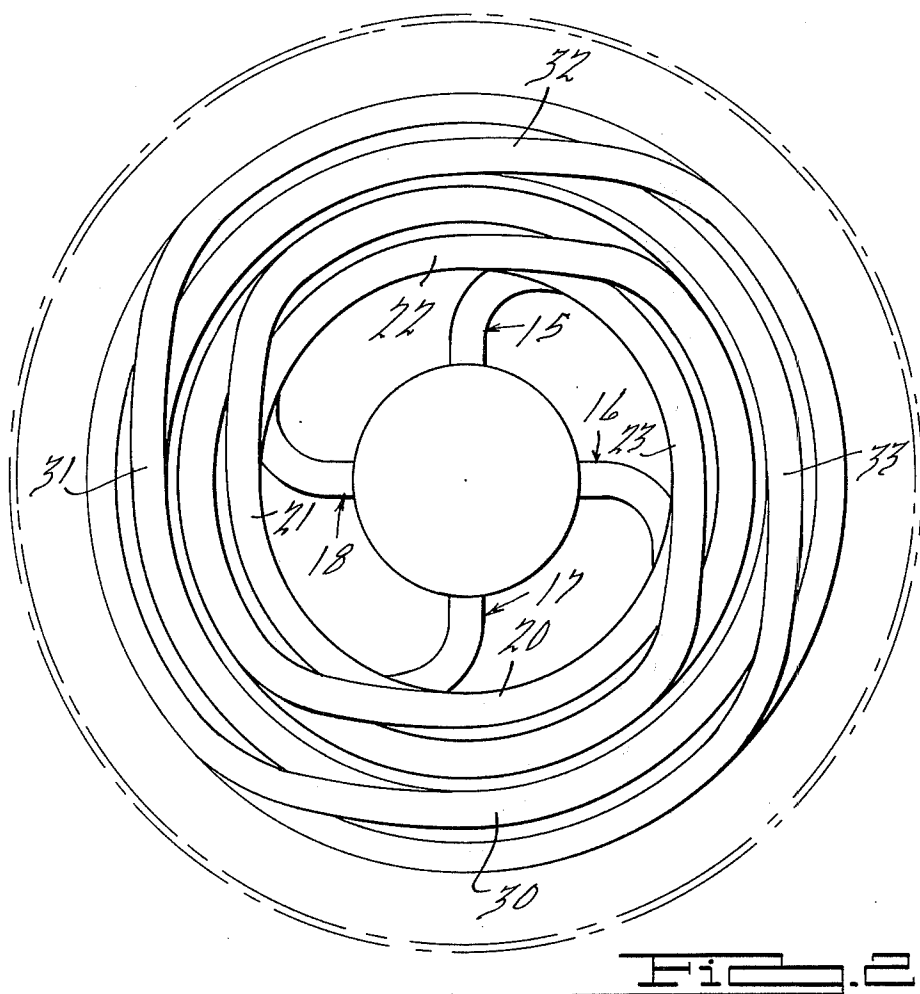
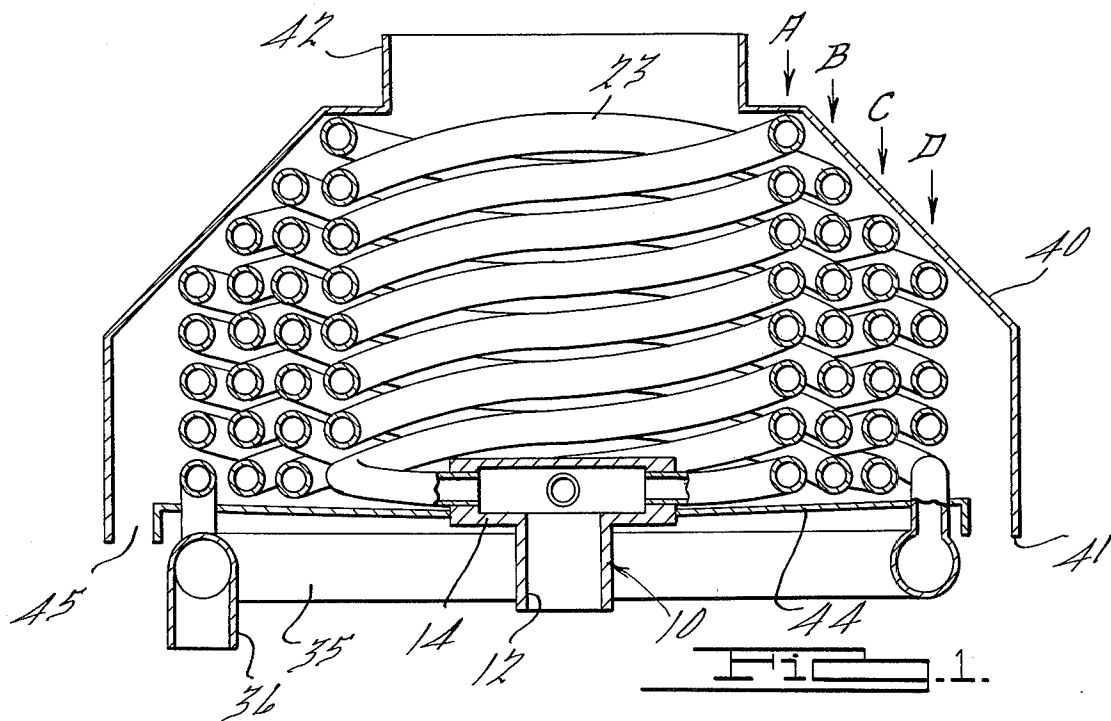
ABSTRACT

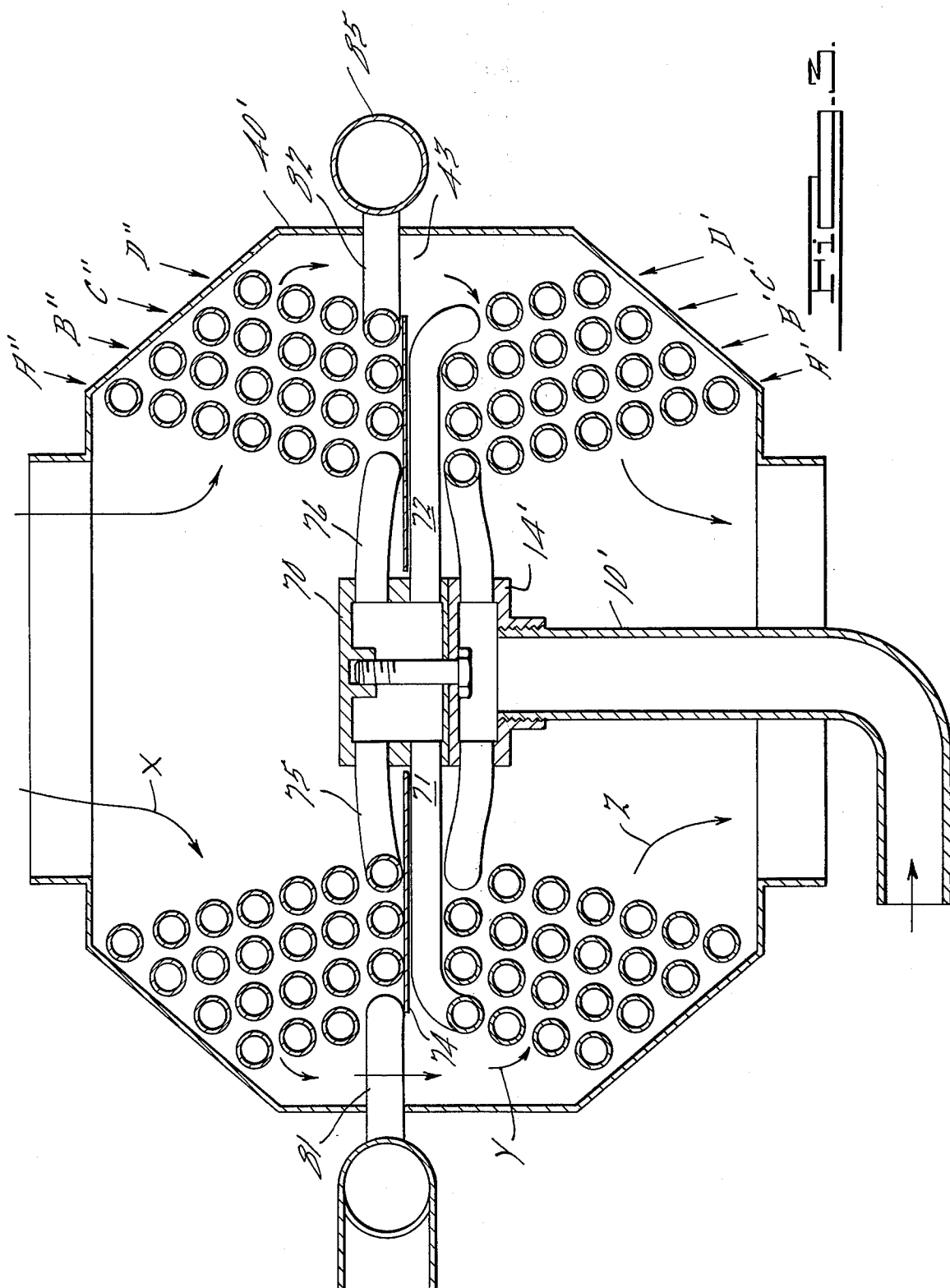
A vapor generator, particularly for organic fluids, has a plurality of tubes constituting parallel flow paths. The tubes are wound in interfitted multilayer helices and each tube is of the same length, configuration and flow resistance.

11 Claims, 3 Drawing Figures



SHEET 1 OF 2





VAPOR GENERATOR

BACKGROUND OF THE INVENTION

Attempts to use certain organic fluids as working agents in Rankine cycle heat engines has presented problems not usually encountered in designing a vapor generator for the traditional Rankine engine agent, water. For small to moderate size Rankine engines using water, a single pass monotube vapor generator is often used for reasons of simplicity and fluid dynamic stability. For Rankine engines of all but the smallest size using organic fluids, the monotube vaporizer becomes impractical because the volume and mass flow rate of the fluid is too large to pass through a single tube of reasonable size. Increasing the tube size produces an unfavorable heat transfer surface to volume ratio, and the vaporizer becomes large and heavy. Therefore, for organic fluid Rankine engines and larger size water steam Rankine engines it becomes desirable to provide several parallel flow paths for the working fluid through the vaporizer. If the several flow paths are not of equal length and flow resistance and are not equally exposed to the heating fluid (usually combustion products) the mass flow and vapor temperature will vary between the paths. Uneven heating between parallel tubes may also cause dynamic flow instability in the vaporizer.

The maximum allowable vapor temperature of organic fluids is limited by undesirable chemical decomposition, but for reasons of thermal efficiency it is usually desired to operate with mean vaporizer discharge temperatures near the allowable limit. The maximum allowable water steam temperature, on the other hand, is often limited by the metallurgical stress-temperature limits of the vaporizer tubing. In both cases, however, local hot spots and uneven temperature distributions between parallel flow paths should be avoided. An optimum vaporizer will therefore have all parallel path tubes of equal length and shape, and equally exposed to the path of the heating fluid.

A second desirable characteristic of a vapor generator heat exchanger is to have a highly turbulent gas path of relatively constant flow area to provide maximum heat transfer for a given surface area and minimum gas pressure drop.

With the foregoing considerations in mind, the overall objective of the present invention may be summarized as to provide an improved, compact and efficient vapor generator of simple construction and low cost, particularly suitable for but not limited to the vaporizing of organic fluids, and which largely overcomes the problems referred to.

Other objects and advantages will become apparent upon consideration of the present disclosure in its entirety.

BRIEF DESCRIPTION OF THE FIGURES OF DRAWING

FIG. 1 is a diametric sectional view of a vapor generator embodying the invention;

FIG. 2 is a plan view thereof with the casing removed; and

FIG. 3 is a view similar to FIG. 1 showing a modified construction.

DETAILED DESCRIPTION OF PREFERRED FORMS OF THE INVENTION

A manifold distribution block or header generally

designated 10 is positioned axially of the several helically coiled generating tube portions through which the fluid to be heated is conducted. The header 10 has an axial input nipple portion 12 and a cylindrical distribution chamber-forming portion 14. In the preferred constructions shown, four tubes, 15, 16, 17 and 18 are provided, each of which has an input end connected to the peripheral wall of chamber portion 14 and spaced equidistantly therearound to receive fluid therefrom. As shown in FIG. 1, the four tubes are wound, parallel to each other and upwardly, as viewed in the drawing, to define a four-tube inner helix, aligned with the arrow A in that view. At the upper end the tubes are carried outwardly and downwardly through helically spiraled integral connecting portions, corresponding to the portions designated 20, 21, 22 and 23 in FIG. 2, all of such connecting portions being alike. From the outer ends of such connecting portions the tubes are wound downwardly as a similar but shorter and radially outspaced four-tube helix, defining a second and reversed helical path, which is aligned with the arrow designated B in FIG. 1. It will be noted that the connection portions 20-23 extend downwardly as well as outwardly so that the helix B is shorter than helix A. At the lower end of helix B the tubes extend outwardly in a similar smoothly curved spiraled fashion, but substantially perpendicular to the axis, to a third reversed or upward helical pass C, which is again shorter at the end which is shown uppermost in FIG. 1, and at the upper end of helix C the tubes are similarly extended outwardly and downwardly via integral helically spiraled connecting portions 30, 31, 32, 33 to a fourth reversed or descending helical pass D. The winding is in the same angular direction throughout, so that the interfitted helix layers are alternately right and left hand, tending to cross each other as viewed radially (FIG. 1) to create maximum effective wiping contact between the heating fluid and the tubes.

The free ends of the tubes at the lower end of pass D are connected at equiangular distances to a collection header ring 35 from which the heated fluid is adapted to be taken through a suitable connection nipple 36.

By virtue of this arrangement all of the tubes may be of the same length and of the same configuration and the arrangement is such that parallel fluid flow through all of the tubes is uniform.

The tubes are enclosed in a casing 40 of circular cross section having an axial duct connecting portion 42 at one end. The diameter of the portion 42 is slightly smaller than the internal diameter of helix A. At the other end of the assembly, corresponding to the end at which the tubes are connected to the header 10, the tube ends lie substantially in a plane perpendicular to the axis, and a flat wall 44 is provided of a diameter less than the internal diameter of the free lower end 41 of casing 40. An annular gas passage 45 is thereby provided between the rim of wall 44 and the end 41 of casing 40. By virtue of this arrangement the heating gases or other heating fluid may be fed inwardly through the connection 42 and will be conducted radially outwardly through the banks of tubes. The tube turns are uniformly spaced from one another. It will be noted that the fluid in each tube traverses the gas path from top to bottom and circumferentially several times. The temperature and/or velocity profile of the entering gases need not be uniform in order to provide equal heating of the conduit flow paths. No sharp turns or

short radius bends are required and frictional flow losses are minimized.

In forming the tubing to the desired configuration it has been found that mild steel tubing can be wound on a suitable mandrel to define helix A, all four tubes being wound at the same time. Thereafter the next helix B is wound downwardly over helix A and directly on top of helix A, and the several helices are similarly successively overlaid. The spring-back of the tubing is sufficient to cause the tubes of each of the helices to move outwardly from one another, although adjustments can be made if desired. Spacing of the convolutions in an axial direction may be assisted by means of radial pins projecting from the mandrel.

In the modified construction shown in FIG. 2 two similar vaporizer sections are provided, back-to-back, the formation of each section being basically similar to that of the first-described embodiment. The passes (A', B', C', D' of the lower section and A'', B'', C'', D'' of the upper section) are wound in a helico-spiral configuration, however, corresponding to a relatively steep frustum of a cone, so that each bank lies more nearly perpendicular to the gas path, which is diagrammatically represented by the arrows X, Y and Z.

The fluid to be heated is fed into the unit axially through conduit 10' and delivered from the cylindrical chamber header 14' to the upper ends of the tubes of the innermost lower helico-spiral bank A', previously mentioned. The tubes are led to and wound in the successively reversed similar but progressively shorter banks B', C', D' in sequence. From the upper end of bank D' the tubes extend inwardly in a radial direction to an axially positioned connection header 70 formed as an extension of input header 14' and to which the tubes are similarly connected at equiangularly spaced positions, by means of connecting portions, only two of which are shown, designated 71 and 72.

A concentric gas baffle disc 74 encircles the connector housing 70 above the output tube portions 71, 72, etc., of the lower section and is of less diameter than the internal diameter of casing 40' to leave an annular gas transfer passage 43 between the sections near the periphery.

The connector housing 70 delivers the fluid to the lower ends of similarly equally spaced input tube portions, only two of which are shown, designated 75 and 76, which are conducted upwardly to define the innermost upper tube bank A''. The successively shorter banks B'', C'', D'' are similarly innerconnected to and each forms a radially outspaced continuation of the preceding tube bank. At their terminal ends, located near the center of the assembly, the tubes of the bank D'' extend outwardly via connecting portions as 81, 82 to an annular collector manifold 85 which encircles the assembly.

The casing 40' will be seen to be basically similar to a double and oppositely reversed pair of casing portions corresponding to the casing 40 of the first-described embodiment.

The word "helix" as used in the specification and claims hereof is intended to include coils wound upon surfaces which are not truly cylindrical. Similar functioning can be obtained with shapes which deviate from the true geometric definition of a helix, as exemplified in FIG. 3, provided all of the tubes of the system correspond in all essential respects, and are fed and exhausted symmetrically or uniformly.

It will also be appreciated that while in the systems described herein four tubes are employed in parallel, a greater or lesser number may be utilized. Further, although two stacked boiler units are disclosed in the embodiment of FIG. 3, additional units may be added by further stacking, as will be appreciated, and other changes may be made without departing from the true invention contained in the preferred embodiments disclosed.

This Detailed Description of Preferred Forms of the Invention, and the accompanying drawings, have been furnished in compliance with the statutory requirement to set forth the best mode contemplated by the inventor of carrying out the invention. The prior portions consisting of the "Abstract of the Disclosure" and the "Background of the Invention" are furnished without prejudice to comply with administrative requirements of the Patent Office.

What is claimed is:

1. A tubular vapor generator including a plurality of vapor generating tubes all of which are of the same length and diameter and each of which has at least a portion thereof in the form of a helix, all of the helices being of the same size and lead and the tubes being interthreaded with respect to one another with the proximate convolutions of each helix spaced from one another in an axial direction, and manifold header means for feeding fluid uniformly into all of such tubes at one end thereof and for withdrawing fluid from the other ends thereof.
2. A vapor generator as defined in claim 1 including a plurality of interfitted radially spaced helices defined by an intermediate tubular portion of each of said tubes.
3. A vapor generator as defined in claim 1 including a plurality of interfitted radially spaced helices defined by an intermediate tubular portion of each of said tubes, each tubular portion in each helix being in series with a corresponding tubular portion in a radially adjacent helix.
4. A vapor generator as defined in claim 1 wherein the manifold header means for feeding fluid into the tubes comprises an axially positioned chamber, the tubes having their inlet ends connected thereto at uniformly peripherally spaced positions.
5. A vapor generator as defined in claim 3 wherein the radially spaced helices are formed by winding all of the tubes continually in one angular direction first in one axial direction in the form of a multi-tube helix, and then in the opposite axial direction but in the same angular direction to form an additional overlying radially spaced helix, each tube having an integral intermediate spiraled joining portion connecting the portions thereof lying in the different helices.
6. A vapor generator as defined in claim 3 including baffling means for guiding a heating fluid in a generally radial direction over the exteriors of the tubes and between the convolutions of the helices.
7. A vapor generator as defined in claim 5 including baffling means for guiding a heating fluid in a generally radial direction over the exteriors of the tubes and between the convolutions of the helices.
8. A vapor generator as defined in claim 5 wherein the helices are of different lengths and the joining portion is of helico-spiral form.
9. A vapor generator as defined in claim 5 wherein the helices are wound on a generally conic surface.

5

10. A vapor generator as defined in claim 8 wherein the helices are wound on a generally conic surface and guiding and housing portions for directing a heating fluid axially of the exterior of one of the helices and axially of the interior of the other helix and generally radially through the helices between the convolutions thereof.

6

11. A vapor generator as defined in claim 10 including an additional pair of overlying helices axially spaced from the aforementioned overlying helices, said guiding and housing portions directing the heating fluid radially outwardly through one of said pairs of helices and inwardly through the other.

* * * * *

10

15

20

25

30

35

40

45

50

55

60

65

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,874,345 Dated April 1, 1975

Inventor(s) Ernest R. Earnest

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Name of Assignee: "The Hydrogen Corporation" should be --The Hydragon Corporation--.

Column 3, line 38, "enncircles" should be --encircles--.

Column 3, line 40, "less" should be --lesser--.

Signed and sealed this 15th day of July 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks