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Long et al.
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[54] **APPARATUS FOR PRODUCING SUPER HEATED FLUIDS**

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[51] **Int. Cl.** **H05b 9/06**, B60k 3/00
[58] **Field of Search** .... 180/67; 219/10.55, 219/10.51, 10.65; 285/363, 364, 368; 287/129, 130; 122/6 A; 165/81

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Assistant Examiner—Hugh D. Jaeger
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[57] **ABSTRACT**

The disclosure relates to an apparatus for producing super heated fluids by converting electromagnetic energy into thermal energy within the fluid. A coil of low dielectric tubing is placed in a microwave resonant chamber and extends from a fluid inlet to a vapor outlet. The fluid to be super heated passes through the coil and is vaporized directly by microwave energy. The invention is particularly applicable to a vapor powered vehicle that produces no environmental pollution.

7 Claims, 4 Drawing Figures

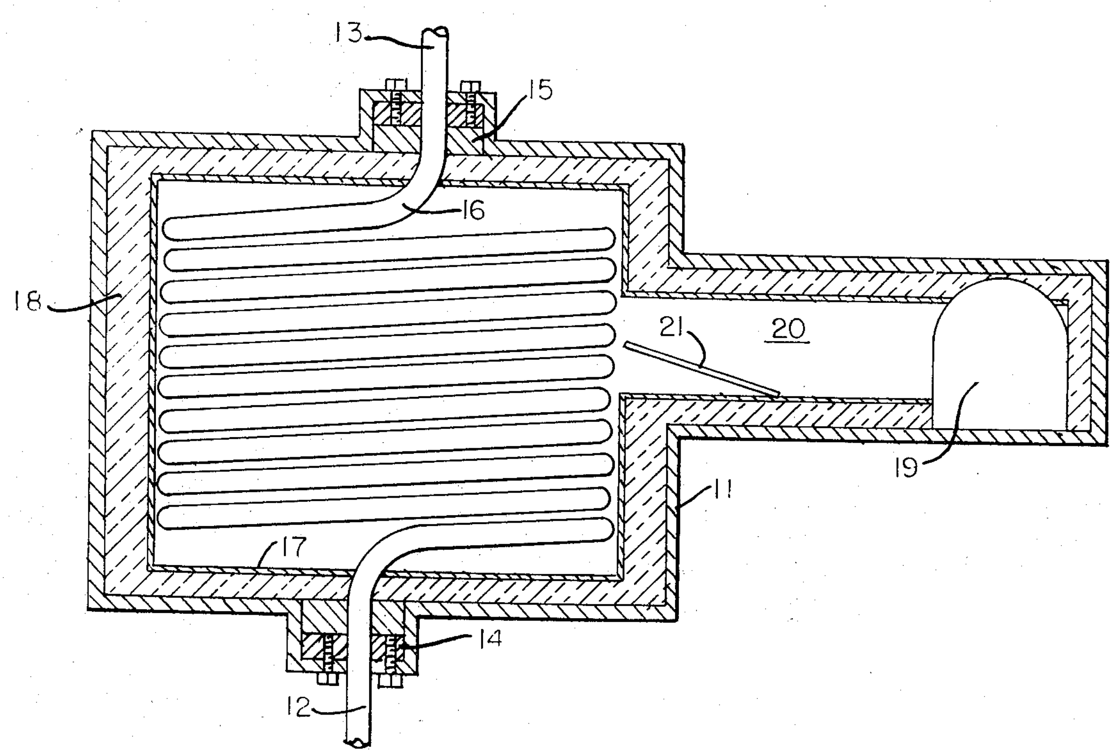


FIG. 1.

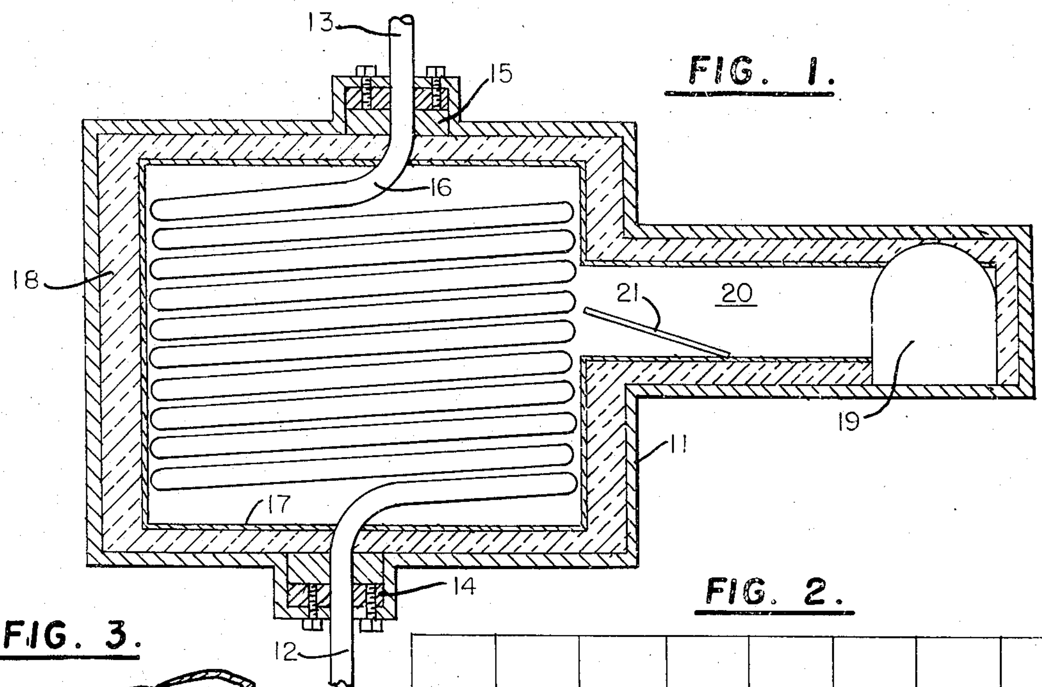


FIG. 2.

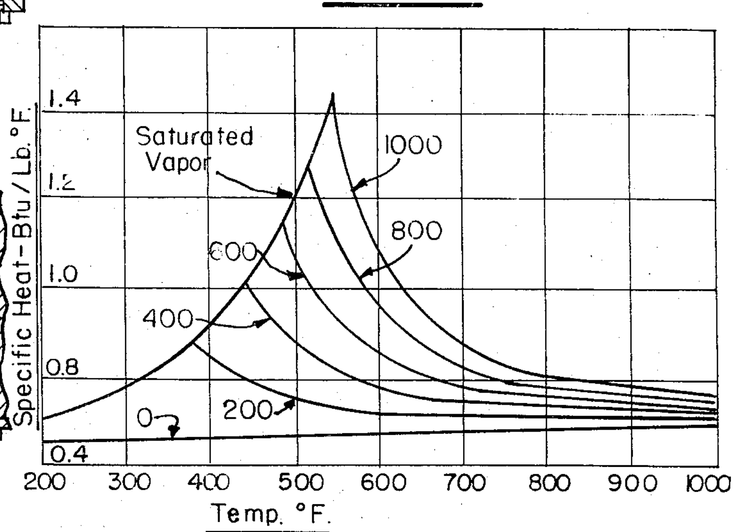


FIG. 3.

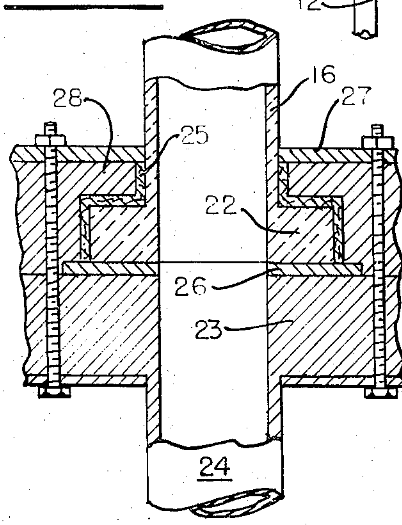
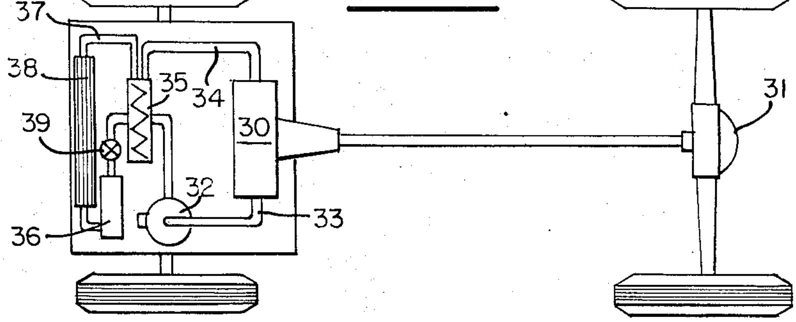


FIG. 4.



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APPARATUS FOR PRODUCING SUPER HEATED FLUIDS

BACKGROUND OF THE INVENTION

One of the primary drawbacks to present vapor or steam driven automobiles is the warm-up time necessary to vaporize the liquid before the vehicle may be moved. While a variety of various methods have been proposed for heating this fluid, none have involved the successful application of microwave energy.

Microwave energy has been used in the past upon repeated occasions for heating solids and fluids. For example, U.S. Pat. No. 3,535,482, issued to J. H. Kluck, on Oct. 20, 1970, illustrates a microwave source for rapidly heating a fluid to be pasturized, and then recooling it again. This reference discloses a method of heating fluids to temperatures above their boiling points while they are under pressure to destroy bacteria and the like. It envisions that the fluid would be subjected to the microwave heating for an exposure time in the order of 0.1 to 0.01 of a second.

U.S. Pat. No. 2,978,562, issued to H. D. Fox, on Apr. 4, 1961, illustrates an instantaneous water heating system wherein the water heater heats the fluid on demand, and does not maintain or store a large body of heated water for domestic use. It discloses a spirally wound plastic tubing with a microwave source centered therein which is energized when the water begins to flow.

None of the prior art references disclose or teach an apparatus for providing super heated fluids for heating fluids at pressures and temperatures far in excess of the normal temperature-pressure vaporization curves. These references do not disclose as their end or terminal product a super heated fluid in the vapor state. The super heated nature of the vapor has proved very advantageous in conveying the maximum amount of energy from the energy source to the vapor turbine or steam engine. The super heated nature of the vapor, and the amount of energy required to generate the super heated vapor would destroy the conventional prior art apparatus if an attempt were made to generate the super heated vapor with it.

SUMMARY OF THE INVENTION

It is therefore an object of this invention to provide an apparatus which will utilize microwave energy to generate super heated vapor at high pressure levels. This apparatus will find particular application in pollution free motor vehicles where the instantaneous generation of vapor or steam is desirable.

It is another object of this invention to provide an apparatus that will withstand the high pressures and temperatures at which it is intended to operate. The apparatus envisions the use of a borosilicate tube which is prestressed in its coil form to normalize those stress loadings when the device is operating at its intended pressure and temperature levels. This coil is freely suspended within the microwave resonant chamber to provide for expansion and contraction of coil as it is heated. The microwave generating source is removed from the resonating cabinet and connected therewith by means of a wave guide to prevent the destruction of the magnetron which would normally occur if the magnetron were exposed to the energy levels that will be present in the resonating cavity when the device is operating at its intended pressure and temperature levels.

A wave guide means and deflector further assist in directing the microwave energy to a specific region of the coil to ensure that the vapor leaving the coil is free from any suspended moisture or fluid droplets.

Although the device is intended to operate in very high pressure levels and very high temperature levels, it is quite apparent that the output of the device is variable between 1 and 1,000 psig, and from 0° to 300° or 400° F of super heat, beyond the normal temperature-pressure variation curve.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagramatic cross section view of the apparatus for producing super heated vapor according to my invention.

FIG. 2 is a chart illustrating the specific heat in BTU's per pound per degree Fahrenheit for water vapor at five levels of constant pressure.

FIG. 3 is a cross sectional view of the glass to metal joint wherein the borosilicate glass tubing is attached to the fluid inlet and vapor inlet of the resonant chamber.

FIG. 4 is a diagramatic plan view of a vehicle with a vapor engine, and a device for producing super heated vapor in accordance with this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 discloses the apparatus for generating super heated vapor. While the description of this apparatus and its operating temperatures and pressures will be for the generation of water vapor, it is to be understood that any suitable fluid may be used. Only the operating parameters would be changed.

The generating apparatus is contained within casing **11** and defines a water inlet **12** and a vapor outlet **13.** The inlet and outlet are connected by means of flanges **14** and **15** to a length of borosilicate tubing **16** which is helically coiled and completely enclosed within casing **11.**

Surrounding the borosilicate coil is a reflective layer **17** which is designed to reflect the microwave energy, and cause it to resonate within the chamber defined by reflective layer **17.** An insulating and vibration absorbing layer **18** surround reflective layer **17** and provides not only insulation for the extremely high temperatures at which the device is intended to operate, but also provides a shock absorbing or movement absorbing means for dampening vibrations caused by sudden movements of the generator when the generator is mounted in a motor vehicle. The borosilicate coil **16** is freely suspended between flanges **14** and **15** and is not supported by any other means.

The coil **16** is prestressed when it is wound to normalize the stresses when operating at its intended temperature and pressure levels. Thus if the device were intended to operate at 750 psig and 700° F then the coil would be stressed during its winding so that at those temperatures the stress loads induced in the coil would be completely normal. Borosilicate glass has been selected since at the present time there is no known plastic tubing that will operate at the pressure and temperature ranges intended and not breakdown under microwave energization. It is important that any material selected for coil **16** be essentially transparent to microwave energy, and low dielectric glass tubing is essentially transparent.

The microwave energy used to heat the fluid passing from the water inlet **12** to the vapor outlet **13** is generated by a magnetron tube **19** which is suitably connected to the resonant chamber by means of a wave guide **20.** It is to be understood that any number of microwave generators may be employed, but one example of such a generator is a magnetron tube such as that illustrated at **19** which operates in the range of **600** MHz. The length of the wave guide **20,** its interior dimensions, and the dimensions of the resonant chamber defined by reflective layer **17** are determined by the frequency of magnetron **19.** It has been found necessary to isolate the source of microwave energy from the resonant chamber since if it were placed within the chamber it would be very rapidly destroyed by the amount of microwave energy present therein. A deflecting means **21** is further provided within the wave guide **20** to protect and isolate magnetron **19.** This wave guide also tends to direct the primary waves of energy to the uppermost coils of the borosilicate tubing **16.** This ensures that the fluid passing through coil **16** is vaporized when it leaves outlet **13.** Any drops of moisture or suspended liquid are instantly vaporized at the upper regions since those regions receive the primary burst of energy from the microwave generator.

As was pointed out previously, the device is capable of operating at any pressure and temperature level from 0° to 300° or 400° F of super heat and from 1 to 1,000 psig. Since the net external work that may be performed in a vapor engine or steam engine is proportional to the amount of heat supplied to the substance, and therefore the amount of increase in total heat, it is desirable to operate the steam generator in the super heat region. If heat is added at constant pressure, as in the subject application, no net external work is done and all heat is used to increase the enthalpy of the vapor. Thus the change in enthalpy represents the heat absorbed at constant pressure. Once the steam is transmitted to the vapor engine, be it turbine or piston type, the change in enthalpy produced by the super heat can be converted to useful work by adiabitic expansion within the device.

The device is then intended to operate between the pressure and temperature levels that provide saturated steam, and the pressure and temperature levels which define the critical point for water vapor. The critical point is defined here as pressures higher than the critical pressure, and temperatures higher than the critical temperature, wherein the fluid or vapor exists as a single phase only, and the vapor pressure curve is terminated in the critical point.

As can be noted in FIG. **2,** the specific heat in BTU's per pound per degree Fahrenheit necessary to excite the vapor for each additional degree of super heat drops after the vapor becomes saturated and moves into its super heated state. FIG. **2** illustrates water vapor at 200, 400, 600, 800, and 1,000 pounds per square inch. Each of the curves represents the specific heat necessary to raise the vapor by the temperature indicated on the abscissa of the graph.

The enthalpy, as measured in BTU's per pound for saturated steam is set forth below:

Enthalpy, BTU/lb. for Saturated Steam

	Temperature °F. 381.79	444.59	486.21	518.23	544.61
200 Absolute	1196.9				
400 Pressures		1204.5			
600 Lb.s/Sq.In.			1203.2		
800				1198.6	
1000					1191.8

The enthalpy however for super heated steam as measured in BTUs per pound is set forth below:

Enthalpy, BTU/lb. for Super Heated Steam

	Temperature °F. 200	400	600	800	1000
200	saturated	1210.3	1322.1	1424.8	1528.0
Absolute 400	saturated	saturated	1306.9	1416.4	1522.4
Pressures 600	saturated	saturated	1289.9	1407.7	1516.7
Lb.s/Sq.In. 800	saturated	saturated	1270.7	1398.6	1511.0
1000	saturated	saturated	1248.8	1389.2	1505.1

Since water vapor is readily compressible, and the total amount of vapor in pounds that may be carried in a given sized conduit between the generator and the vapor engine is substantially greater at 1,000 pounds per square inch than 400 pounds per square inch, it is quite apparent that the amount of useful heat increases rather dramatically as the amount of super heat increases, even though the enthalpy for each pound of steam declines.

In the subject invention, the borosilicate glass tubing is designed to operate at these temperatures and pressures. These temperatures and pressures, and the microwave energy do present specific engineering problems in the instant application. FIG. **3** is a cross sectional view of the flange system **14** and **15** wherein the borosilicate tubing **16** is suspended between the water inlet and the steam outlet. The borosilicate tube **16** has defined on its end portion a flange **22** which mates with a metal flange **23** and metal tubing **24.** This metal shielding prevents the escape of microwave energy to the exterior of the resonant chamber **11.** The borosilicate glass flange **22** is completely surrounded with a packing member **25** and directly abuts a gasket member **26.** The packing material **25** is retained by a slip ring **27** and a two part mating flange **28** which is bolted to the metal flange **23.** The mating flange **28** and ring **27** provide for compression of the packing material **25,** and holds the flange **22** in direct engagement with metallic flange **23.** It also serves to compress gasket member **26.** This elaborate packing mechanism is designed not only to prevent the escape of super heated steam at very high pressure, but is also designed to provide a resilient mount for the borosilicate tubing **16** and provide for expansion of the tubing **16** as it is heated by the water vapor. As pointed out previously, the tubing **16** is completely supported between the inlet **12** and the outlet **13** by means of the flange members illustrated in FIG. **3.** It is completely free floating and this is again intended to allow for expansion of the tubing at its intended operating level. The insulating and shock absorbing means **18** which is placed between the reflective layer **17** and the outer casing **11** serves to support the tubing horizontally, and prevent any excess horizontal motion when the device is placed in a motor vehicle.

FIG. **4** illustrates a motor vehicle equipped with a vapor or steam engine **30** and conventional differential and axle means **31**. The steam engine **30** may be a steam turbine, or one of the many varieties of expansion chamber motors currently in use. Super heated steam is produced for this vapor engine by means of the apparatus illustrated in FIG. **1** and indicated by the numeral **32** in FIG. **4.** Conduit **33** provides a passage way for the super heated steam and conduit **34** provides an outlet for the exhaust steam. The exhaust steam is used in heat exchanger **35** to heat the incoming water that passes from the water storage chamber **36** through heat exchanger **35** to the super heated steam generator **32.** After preheating the water or other fluid, the steam is then exhausted through conduit **37** into condensor **38** mounted at the front of the automobile. After being condensed back to its liquid form it is collected in the liquid storage tank **36** for reuse within the system via a pump **39.** As pointed out previously, steam and water vapor have been used for purposes of illustration, although it is quite apparent that any other liquid and vapor that would provide the desired temperature and heat characteristics could be used.

While specific means have been illustrated in specific examples and mentions given herein, it is to be understood that various modifications of this system or the operation thereof would occur to one skilled in the art. Accordingly it is understood that the present invention is not limited to these illustrations and examples, but is to be limited only in accordance with the appended claims.

We claim:

1. Means for producing superheated vapor including

a. means for generating microwave energy,

b. a microwave resonating chamber, said chamber having shielding means to prevent the escape of microwave radiation, said chamber having reflecting means mounted within said chamber, said chamber defining fluid inlet and vapor outlet means, the dimensions of the chamber being matched to the frequency of the means for generating microwave energy to provide a resonant chamber for said energy,

c. a coil of low dielectric tubing mounted within said chamber, said tubing connecting said fluid inlet and said vapor outlet means, and

d. wave guide means connecting said microwave generating means with said resonant chamber to direct said microwave energy to the exterior of said coil, said energy directed towards the coil adjacent the vapor outlet.

2. Means for producing superheated vapor as claimed in claim **1** wherein said coil is formed of glass tubing, said tubing being prestressed during the formation of said coil to allow unloading of said stress when said coil is subjected to its design temperature and pressure.

3. Means for producing superheated vapor as claimed in claim **1** wherein protective means are inserted between said resonating chamber and said means for generating microwave energy.

4. Means for producing super heated vapor as claimed in claim **1** wherein said coil is formed of borosilicate glass.

5. Means for producing super heated vapor as claimed in claim **4** wherein said coil is suspended within said resonant chamber and anchored only at said fluid inlet and vapor outlet.

6. Means for producing super heated vapor as claimed in claim **5** wherein said coil is mounted to said inlet and outlet by flanges defined on either end of said coil, each of said flanges being abutted against a similar metal flange, a retaining means for clamping said glass flange to said metal flange with shock absorbing material completely surrounding said glass flange.

7. Means for producing super heated vapor as claimed in claim **5** wherein said coil is suspended within said chamber and cushioned against any lateral movements by a shock absorbing means surrounding said coil.

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