

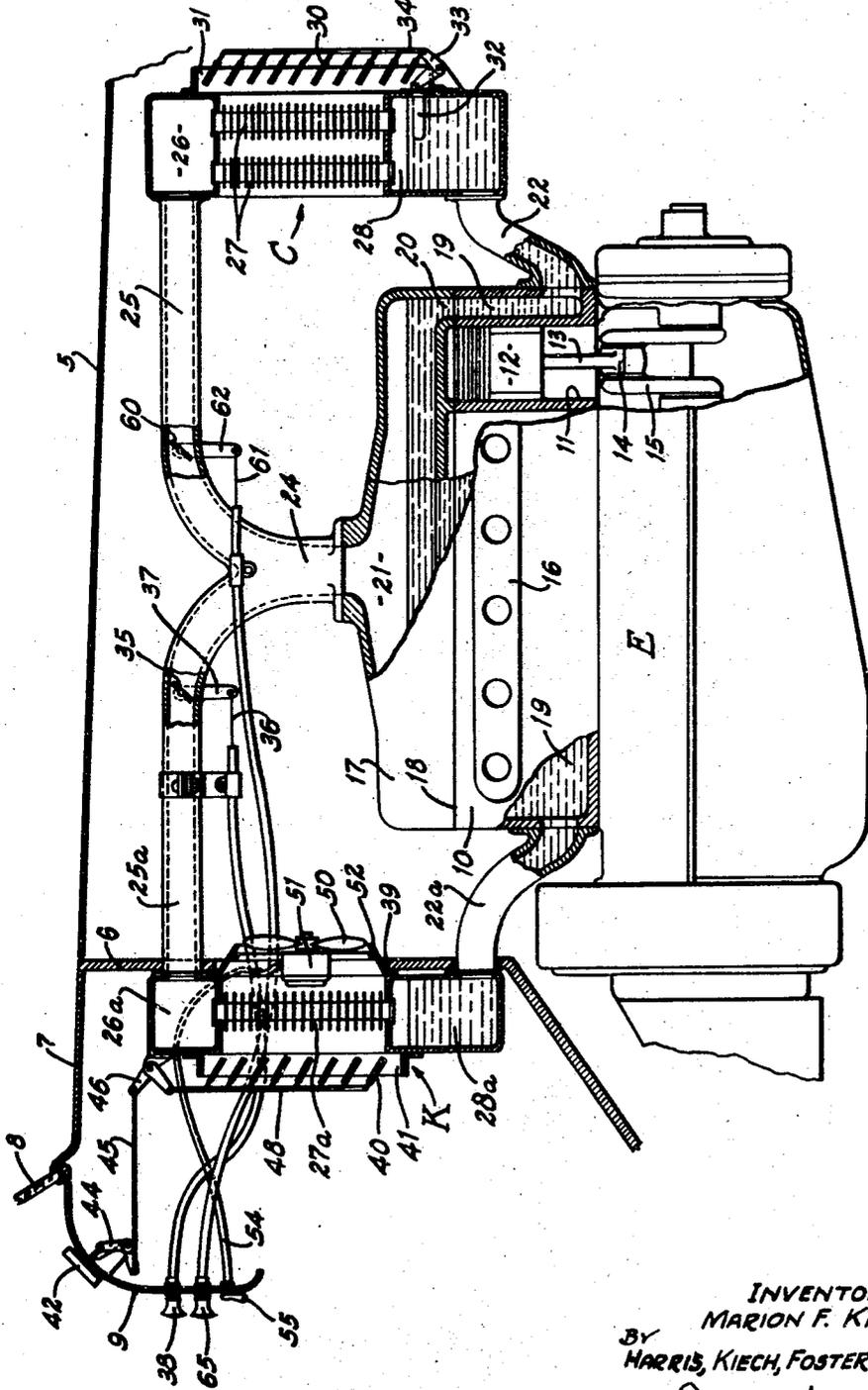
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VAPOR-LIQUID COOLING CYCLE FOR ENGINES

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VAPOR-LIQUID COOLING CYCLE FOR ENGINES

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This invention relates to the dissipation of heat for cooling internal combustion engines and the like, including gas turbines.

The principal object of the invention is to effect efficient and dependable regulation of motor temperature through the boiling of certain types of liquids in a sealed motor cooling circuit so that the boiling point of a given liquid under the pressure of the closed system automatically controls the temperature of the motor, atmospheric pressure conditions having no effect in the sealed circuit.

Other objects of the invention are to eliminate the freezing hazard in automobile engine cooling, to eliminate the necessity for a liquid circulating pump between the motor jacket and the radiator, and to avoid the necessity of frequent replenishment of motor cooling liquid as is now common.

Other objects and advantages will appear from the following disclosure.

Briefly stated, the invention resides in employing a closed or hermetically sealed cooling system wherein there is permanently contained a cooling liquid of appropriate boiling point. According to a preferred form of the invention, the liquid is a mixture having a constant boiling temperature, and, according to a further preference, one element of the mixture is water. Usually the boiling point of the mixture is below the boiling point of water, whereby to establish the boiling point at the most efficient temperature for operation of a given engine, for example, at around 180° F., but it may approximate the boiling point of water for some uses.

Another phase of the invention resides in the employment of a sealed vapor condenser at an elevation above the motor, whereby the condensate from the vapor of the cooling liquid returns to the motor by gravity feed. This condenser may conveniently conform in general with the modern type of automobile radiator so long as the condensing portion is located at said elevated position so as to return the condensate to the motor.

In the accompanying drawing, there is illustrated diagrammatically one embodiment of a system in which the present invention is practiced.

In the drawing, I show a hood 5 of an automobile having a dashboard 6 at the rear of the hood, together with a cowl 7, a windshield 8 thereabove, and an instrument panel 9. Under the hood 5 there is shown a conventional internal combustion engine E having an engine block 10

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which is connected with a condenser C located in a cooling position under the forward end of the hood, and with a second condenser K behind the dashboard 6 where it may heat the driver's compartment, these parts constituting the principal units of the system.

The engine block 10 has the usual cylinder bores 11 in which pistons 12 are reciprocated by means of connecting rods 13 having bearings 14 conventionally mounted upon a crank shaft 15 for propelling the automobile in the usual manner. The engine block carries a unit manifold 16 for supplying fuel to the engine and removing exhaust gas, as is common in a typical internal combustion engine. Also provided is a head 17, constructed somewhat after the fashion of a conventional engine head, secured to the engine block 10 in any known or preferred manner, and sealed in relation thereto by means of a conventional gasket 18.

The engine block 10 is provided with a series of water passages 19 constituting a cooling jacket receiving the cooling liquid, as is well known in the art, which passages 19 extend vertically in the block and communicate with passages 20 in the head 17, the passages 20 in turn leading to a chamber 21 in said head 17. The head 17 is of such proportions and construction that the chamber 21 provides for the maintenance of a liquid level at an intermediate point with a vapor space thereabove. A cooling liquid, such as that hereinafter described, is supplied to passages 19 by means of a liquid supply line 22 which communicates with the bottom of the passages 19 as shown.

Since cooling of the engine during operation is effected by vaporization of the cooling liquid, after the engine has warmed up in operation quantities of the liquid vaporize in the passages 19 and the vapors rise through the liquid to the surface thereof in the chamber 21 where they separate and accumulate in the top of the chamber 21 passing thence by way of a neck 24 into a vapor line 25 which leads to a vapor receiving space 26 in the top of the condenser unit C. The intermediate portion of the condenser C below the vapor receiving space 26 constitutes a condenser section 27 comprising coils or tubes wherein vapors passing downwardly from the receiving space 26 are condensed into liquid. The condensate accumulates by gravity in a liquid receiver 28 constituting the lower portion of the condenser C. As liquid is vaporized in the engine block 10, liquid condensate flows by gravity from the liquid receiver 28 to the supply line 22

and through the passages 19 in the engine block 10, thereby continuously supplying cooling liquid for further vaporization, heat being absorbed from the engine block by reason of the amount of heat necessary to convert the liquid therein into vapor.

The condenser C is air cooled and is located in the upper portion of the forward space under the hood normally occupied by an ordinary automobile radiator. The condensing section 27 is high enough so that liquid condensed therein will flow back to the engine by gravity, and its structure may be of any suitable design, such as the common cellular construction or one of the common tubular constructions provided with fins as shown, or hairpin coils provided with fins. When desirable to regulate the cooling in the condenser C, adjustable louvers 30 are preferably positioned in front of the condenser C, the louvers being subject either to manual or thermostatic control as may be deemed suitable, although it will be understood that such louvers are not essential in view of the fact that the operation of the system is largely automatic and that such louvers merely provide a closer temperature control. As shown, the louvers 30 are pivoted in a louver housing 31 on the front of condenser C, and a thermostatic control is illustrated where a thermostat 32 inset in the receiver 28 actuates a bell crank 33 which in turn actuates a louver-adjusting rod 34 connected with the louvers 30.

Inasmuch as there is a very considerable amount of heat that is taken from the engine 10 and commonly wasted to the atmosphere through the condenser section 27 of the condenser C, it may be desired at times to take advantage of some or all of this heat for heating the passenger space or driver's compartment in the automobile body. This may be conveniently accomplished by providing a branch line 25a leading from the neck 24 on the cylinder head 17 to carry some or all of the vapors therefrom into the second condenser K which may be suitably mounted within the car body, for example, on the rear of the dashboard 6 as shown. This condenser K is a substantial duplicate of the condenser C, having an upper vapor receiving space 26a, a condenser section 27a, a liquid receiving chamber 28a, and a liquid return line 22a leading to the bottom of the engine block 10 to communicate with the passages 19. The condenser K may be cut in or out of the system by a valve 35 mounted in the line 25a and actuated through the medium of a housed cable 36 which is connected at one end with an arm 37 operating the valve 35 and has its other end mounted in the instrument panel 9 where it is provided with a control 38 located in the driver's compartment for convenient manipulation. When condenser K is made operative by opening valve 35, the system constitutes both a cooling device for the engine and a heating device for compartments in the car.

The heating effects of the condenser K may be regulated by controlling passage of air through the condenser section 17a. This is accomplished in the form shown by providing an opening 39 in the dashboard 6 in front of the condenser section 27a and placing adjustable louvers 40 immediately behind the section 27a in a louver housing 41 in which they are pivoted. The louvers 40 may be adjusted as desired, for example, by means of a thermostatic control 42 mounted on the instrument panel 9 and responsive to temperature in the driver's compartment. The thermostat 42 operates a pivoted bell crank 44 actu-

ating a link 45 connected to a second pivoted bell crank 46 which in turn operates a louver-adjusting rod 48 connected with each louver 40. An electric fan 50 and its driving motor 51 are shown positioned in front of the opening 39 within a circular hood 52 for positively directing air through the coils of the condenser section 27a to insure an adequate flow of heated air into the compartment to be heated. An electric cable 54 leads from fan 50 to a switch 55 on panel 9 for controlling the fan.

When desired, all possible heating effects of the vapors may be directed to the second condenser K by cutting the forward condenser C out of its normally operative relation, this being done through the medium of a valve 60 in line 25 corresponding with valve 35 in line 25a, and operable by a housed cable 61 connected at one end with an arm 62 actuating valve 60. The other end of cable 61 extends through the dashboard 6 and is mounted in the panel 9 for operation by a control 65 which may be manually actuated as required.

The operation of the present sealed cooling system involves primarily vaporization of a constant boiling liquid in the passages 19 of the engine block 10, whereby the engine is cooled due to the heat consumed in the vaporization of the liquid. The resultant vapor separates from the liquid in the chamber 21 at the liquid level indicated, rises through the neck 24, and passes through either or both of the condensers C and K, being received in the vapor spaces 26 and 26a respectively thereof, then passing down through the cooling tubes of condensing sections 27 and 27a respectively, the condensate collecting in the respective receivers 28 and 28a, whence the condensate returns by gravity through the lines 22 and 22a to the passages 19 in the engine block 10 to effect further evaporative cooling.

The indicated passage of the vapors selectively through either or both of the condensers C and K is effected by suitable operation of the valves 35 and 60. If the driver's compartment becomes too warm when the condenser K is operating, the louvers 40 will close or partly close and stop or reduce air passage through opening 39 and condensing section 27a. At such a time valve 60 will have been opened by the control 65.

If the temperature in the engine becomes too high, excess vapors are generated, thereby increasing the pressure in the system and raising the temperature of the resultant condensate in receiver 28. This temperature rise affects the thermostat 32 in the receiver 28, thereby causing actuation of the adjusting parts 33 and 34 to open or partly open the louvers 30, as a result of which more cooling air passes through the condensing section 27, thereby condensing the vapors more rapidly, and lowering the pressure in the system, which in turn results in lowering the temperature of the condensate in the receiver 28. Preferably, thermostat 32 is disposed in the upper portion of the body of condensate in receiver 28 so that it always responds to the temperature of the condensate most recently formed.

It will be noted that, with this type of cooling, there is no circulation of liquid as such. Rather, the agent that is circulated is the vapor formed in connection with the cooling of the engine.

Since the system is sealed and the vapor is continuously generated during engine operation and rises from the surface of the liquid in the chamber 21 at a rate varying with the amount of heat produced by the engine, the condensa-

tion of the vapor and the return of the resultant condensate to the engine yield an automatic regulation which insures a substantially uniform engine temperature.

As to the liquid to be employed, there are several liquid mixtures having constant boiling points within a range which is suitable for the present method of cooling internal combustion engines. Appropriate mixtures are those containing water as one constituent and an alcohol, ketone, ester, or similar organic substance as another constituent. As preferred liquids, the following may be employed according to the boiling point desired. Ethyl alcohol and water from a suitable mixture when containing 95.6% by weight of the alcohol and 4.4% by weight of water. This mixture has a constant boiling point of 78.15° C., or about 173° F. Thus, where it is desired to operate an internal combustion engine at a temperature approximating the average now commonly used, this ethyl alcohol mixture may be used. However, in many instances it will be preferable to use higher engine temperatures than have heretofore been commonly employed. Thus, for such a use there is a constant boiling mixture of secondary butyl alcohol and water which contains 72.7% of the alcohol and 27.3% of water, which mixture boils at 189.5° F. or 87.5° C. Again, in some engines a mixture having a boiling point approximating that of water may be more desirable, and such a constant boiling point mixture comprises 12.7% di-acetone alcohol and 87.3% water, this mixture boiling at 210° F. or 98.8° C. These figures may vary slightly from the actual according to different authorities but they satisfy practical purposes. As described hereinafter, under conditions of operation in my system the boiling point of the mixture may rise due to increases in pressure in the system.

The use of the constant boiling point liquid mixtures above indicated will at the same time eliminate the freezing hazard experienced when water is used, because these mixtures constitute good anti-freeze mixtures. Of course, it might be possible to use different mixtures of alcohols and water, and other kindred mixtures, as has often been done heretofore in preparing anti-freeze solutions. However, unless the exact percentages to constitute constant boiling temperature mixtures are employed, there is unequal distillation in the engine and the result is that the boiling point is changing constantly during use and there is no close temperature regulation. Therefore it is highly preferable to use constant boiling temperature mixtures such as those given above or any others having a desired boiling point.

Water is one of the most effective evaporative coolers and has the highest latent heat of vaporization among the ordinary liquids, but in a closed system of the present invention its boiling point may be too high in many instances, and, of course, it presents a freezing hazard because of its high freezing point. Of the liquids to be used with water which are suitable for this purpose and impart a sufficiently low freezing point, while at the same time making suitable constant boiling mixtures with water, ethyl alcohol is very desirable because it has the highest latent heat of vaporization, and at the same time is chemically stable and relatively harmless to metals. Although this constant boiling point mixture contains only 4.4% water, nevertheless ethyl alcohol normally is readily available at moderate price

and, being used in a closed system, is feasible for the present purpose. Where the constant boiling point of the ethyl alcohol mixture is too low, the secondary butyl alcohol mixture becomes desirable because it contains a larger proportion of water (about 27% water) and has a boiling point of about 190° F. Thus, although the latent heat of vaporization of the secondary butyl alcohol is lower than that of ethyl alcohol, nevertheless the increased proportion of water with its very high latent heat of vaporization makes this mixture desirable, especially since it also is a good anti-freeze agent. Where an anti-freeze mixture having a constant boiling temperature in the neighborhood of that of water is required, the previously mentioned di-acetone alcohol mixture may be used because it has an adequately low freezing point and high latent heat of evaporation inasmuch as it contains a high proportion of water (about 87%), although the di-acetone alcohol itself has a very low latent heat of vaporization.

Thus, the three preferred boiling point mixtures described meet all the requirements for motor cooling with evaporative liquids having low freezing points, suitable boiling points, high latent heat of vaporization, chemical stability, and relative harmlessness to metal. By employing constant boiling point liquids of this type, reasonably accurate temperature regulation is assured in a sealed, circulating cooling system, the freezing hazard is avoided, liquid pumps are eliminated, and the necessity for frequent liquid replenishment is likewise overcome.

It might be possible to use ethyl alcohol alone, or perhaps methyl alcohol alone, if no objection were found in the loss of benefits derived from the high latent heat of vaporization of the water content of the described constant-boiling water mixtures constituting the preferred form of this aspect of the invention.

By employing evaporative liquids in a cooling system, greater cooling efficiency is accomplished by taking advantage of the high latent heat of vaporization, over that obtained by simply circulating hot liquids, for the reason that a much greater volume of hot liquid is required to produce the same amount of cooling. As a result of employing the present sealed system, a much smaller amount of liquid, and consequent reduction in weight, is possible inasmuch as the vapors are condensed and the condensate returned to the engine. The condenser is always relatively empty of liquid, in view of the condensation and prompt liquid return, with the result that the entire radiating surface is available for condensation, and with the further result that the amount of radiating surface may be reduced, thereby reducing weight. These conditions are in part a result of the greater efficiency of air cooling to effect condensation of vapor, than to cool liquid contained within a radiator as in the present common water cooling. This is made possible by the fact that a vapor condenser has the same temperature throughout, that is, its temperature is the same from top to bottom, whereas a conventional liquid cooling radiator is relatively cool in its lower portion which therefore dissipates very little heat.

A further advantage resulting from the vaporization of liquid to effect cooling, is the fact that the liquid itself is not circulated, with the result that in heating up a cold engine the attainment of the desired operating temperature is effected quickly.

A further advantage in the employment of a

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constant boiling mixture in a hermetically sealed system is the ability of the system to care for heat over-load. Thus, as more heat is developed in the engine and its temperature tends to increase, the increased heat liberated causes the generation of vapor at a greater rate, and since the condenser will not liquefy the vapor at the normal boiling point of the liquid, the pressure of the system begins to rise. This rise in pressure increases the boiling point and at the same time it raises the condensation temperature in the condenser. The result is that, for a given temperature of cooling air, the heat is dissipated more rapidly due to the removal of more heat units in a given time at that elevated temperature. Also, the resultant increase in vapor density inside the condenser expedites heat dissipation, and the net result of all of these factors is that an equilibrium will be established at a higher temperature and pressure in the condenser, the heat dissipation at that higher temperature thus equalling the rate of heat absorption without undue rise in engine temperature. Therefore, by proper proportioning of the condenser surfaces with respect to the maximum heat load that the system is intended to handle, any heat load above normal that is encountered in practical operation will be readily cared for.

It is to be understood that other embodiments of this invention may be made in the light of the present teachings, and within the spirit of the appended claims, without, however, departing from the broad inventive concept here presented. It is therefore intended that such modifications shall be covered by the claims presented.

I claim as my invention:

1. A method of cooling internal combustion engines and other engines having cooling liquid jackets comprising: supplying to the jacket by means of a closed circuit a liquid vaporizable at a predetermined engine temperature, whereby the engine is cooled by vaporization of the liquid; recovering the resultant vapors; condensing said vapors; collecting the resultant condensate; returning the condensate to said jacket; and maintaining the entire circuit sealed, thereby preventing escape of contained fluids and entrance of extraneous fluids.

2. A method according to claim 1 wherein a head of condensate is established above the level of the engine jacket for gravity feed of liquid to said jacket.

3. A method according to claim 1 wherein said liquid is an anti-freeze mixture having a constant boiling point.

4. A method according to claim 1 wherein said liquid has a constant boiling point and consists of one of the liquids of the following class: (1) approximately 95.6% ethyl alcohol by weight and 4.4% water; (2) approximately 72.7% secondary butyl alcohol by weight and 27.3% water; and (3) approximately 12.7% di-acetone alcohol by weight and 87.3% water.

5. A cooling system for internal combustion engines and other heat generating engines comprising: a cooling liquid jacket for said engine having a liquid inlet at the bottom and a vapor outlet at the top, there being a vapor space in the upper portion of said jacket; and a condenser having a vapor space in the upper portion thereof connected in sealing relation with said outlet of said jacket, said condenser having a liquid space in the lower portion thereof to receive condensate, said liquid space being connected in sealing relation with the inlet of said jacket to return

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condensate to said jacket the entire system being sealed to prevent escape of contained fluids and entrance of extraneous fluids.

6. A system according to claim 5 wherein the liquid space in said condenser is located at least as high as the liquid level position in said jacket, whereby condensate is fed to said jacket by gravity flow.

7. In combination: a vehicle having a body; a heat generating engine in said vehicle for propelling the vehicle, said engine having a jacket to receive cooling liquid, the jacket having an inlet at the bottom and a vapor outlet at the top; a condenser positioned forward of said engine, having a vapor space in the upper portion thereof and a liquid receiving space in the lower portion thereof; condenser means located in said body, said condenser means having a vapor receiving space in the upper portion thereof and a condensed liquid receiving space in the lower portion thereof; means connecting the vapor receiving spaces of said condensers in sealing relation with the vapor outlet of said jacket; and means connecting the liquid receiving spaces of said condensers with the liquid inlet of said jacket in sealing relation.

8. A combination as in claim 7 wherein said jacket includes means providing a vapor receiving space above a normal liquid level position in said jacket.

9. A combination according to claim 7 and means for selectively bringing said condenser means into operative condition for heating the body of said vehicle.

10. A sealed cooling system for heat generating engines comprising: a cooling liquid receiving jacket for the engine having a liquid inlet at the lower portion thereof and a vapor outlet at the upper portion thereof; a condenser means having a vapor space in its upper portion, an intermediate condensing section, and a liquid condensate receiving space in the lower portion; means connecting said vapor space with said vapor outlet in sealing relation; and means connecting said liquid space with said liquid inlet in sealed relation, said liquid space in said condenser means being positioned with respect to said jacket to feed condensate to said jacket by gravity flow.

11. A sealed cooling system according to claim 9 wherein the system is mounted on a vehicle having a body, and said condenser means includes condensing means in said body; and means to place said condensing means in said body selectively in operative condition for heating said body by reason of the heat absorbed from said condensing means in said body.

12. In combination: an automotive vehicle having a body; an internal combustion engine carried by said vehicle and connected to drive said vehicle; a cooling liquid receiving jacket for said engine having a liquid inlet at a lower portion thereof and a vapor outlet at an upper portion thereof; condensing means having a vapor receiving space and a condensing section including a condensate receiving space, said condensing means being positioned in said body of said vehicle for heating said body by means of heat absorbed from said condensing means; means connecting said vapor space with said vapor outlet; and means connecting said condensate receiving space of said condensing means with said liquid inlet of said jacket.

13. A combination according to claim 12 wherein said condensing means is disposed above said

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jacket whereby condensate is fed to said jacket by gravity flow.

14. A combination according to claim 12 wherein said condensing means includes an auxiliary condensing portion located exteriorly of said body and having a vapor space and a condensate receiving space respectively connected with said vapor outlet and liquid inlet of said jacket.

15. A combination as in claim 12 wherein said jacket includes means providing a vapor receiving space above a normal liquid level position in said jacket.

16. A method for cooling a heat generating engine having a sealed cooling system including a liquid jacket, condensing means and circulating connections between said jacket and condensing means, comprising: circulating through said system a liquefiable fluid which has a constant boiling point and consists of one of the liquids of the following class: (1) approximately 95.6% ethyl alcohol by weight and 4.4% water; (2) approximately 72.7% secondary butyl alcohol by weight and 27.3% water; and (3) approximately 12.7% di-acetone alcohol by weight and 87.3% water.

17. A method for cooling a heat generating engine having a sealed cooling system including a liquid jacket, condensing means and circulating connections between said jacket and condensing means, comprising: circulating through said system a normally liquid anti-free fluid mixture containing water and having a constant boiling point.

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18. A method according to claim 17 wherein the constant boiling point mixture employed consists of approximately 72.7% secondary butyl alcohol by weight and 27.3% of water by weight.

19. A method according to claim 17 wherein the constant boiling point mixture employed consists of approximately 95.6% ethyl alcohol by weight and 4.4% water.

20. A method according to claim 17 wherein the constant boiling point mixture employed consists of approximately 12.7% diacetone alcohol by weight and 87.3% water.

21. In combination: a vehicle having a body; a heat generating device carried by said vehicle; a cooling liquid receiving jacket for said device having a liquid inlet at a lower portion thereof and a vapor outlet at an upper portion thereof; condensing means having a vapor receiving space and a condensing section including a condensate receiving space, said condensing means being positioned in said body of said vehicle for heating said body by means of heat absorbed from said condensing means; means connecting said vapor space directly with said vapor outlet; means connecting said condensate receiving space of said condensing means directly with said liquid inlet of said jacket; and auxiliary condensing means located exteriorly of said body and having a vapor space and a condensate receiving space respectively connected directly with said vapor outlet and said liquid inlet of said jacket.

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