April 4, 1939. A. F. UNDERWOOD 2,153,108

STEAM HEATING SYSTEM

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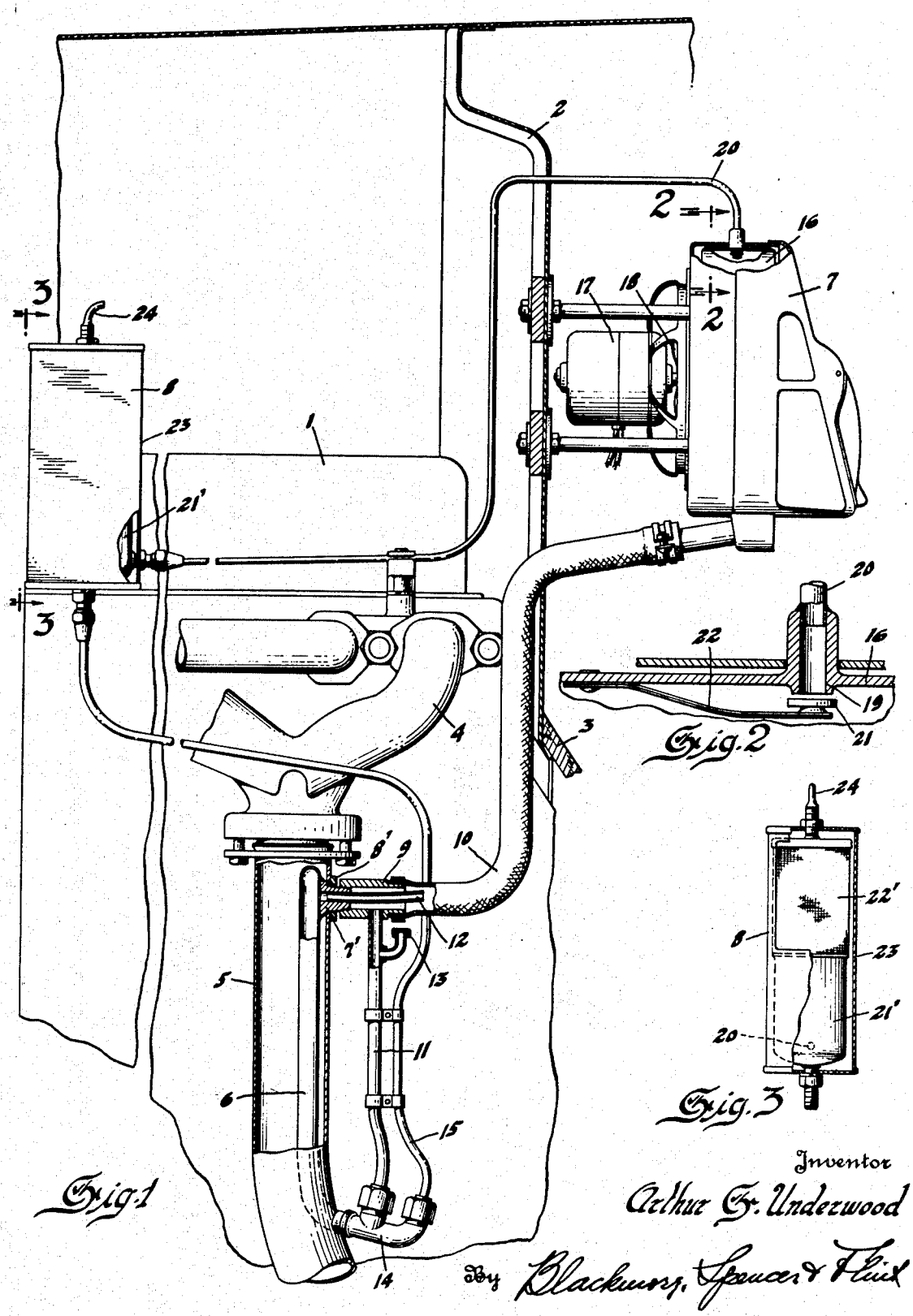


Fig. 1

Fig. 2

Fig. 3

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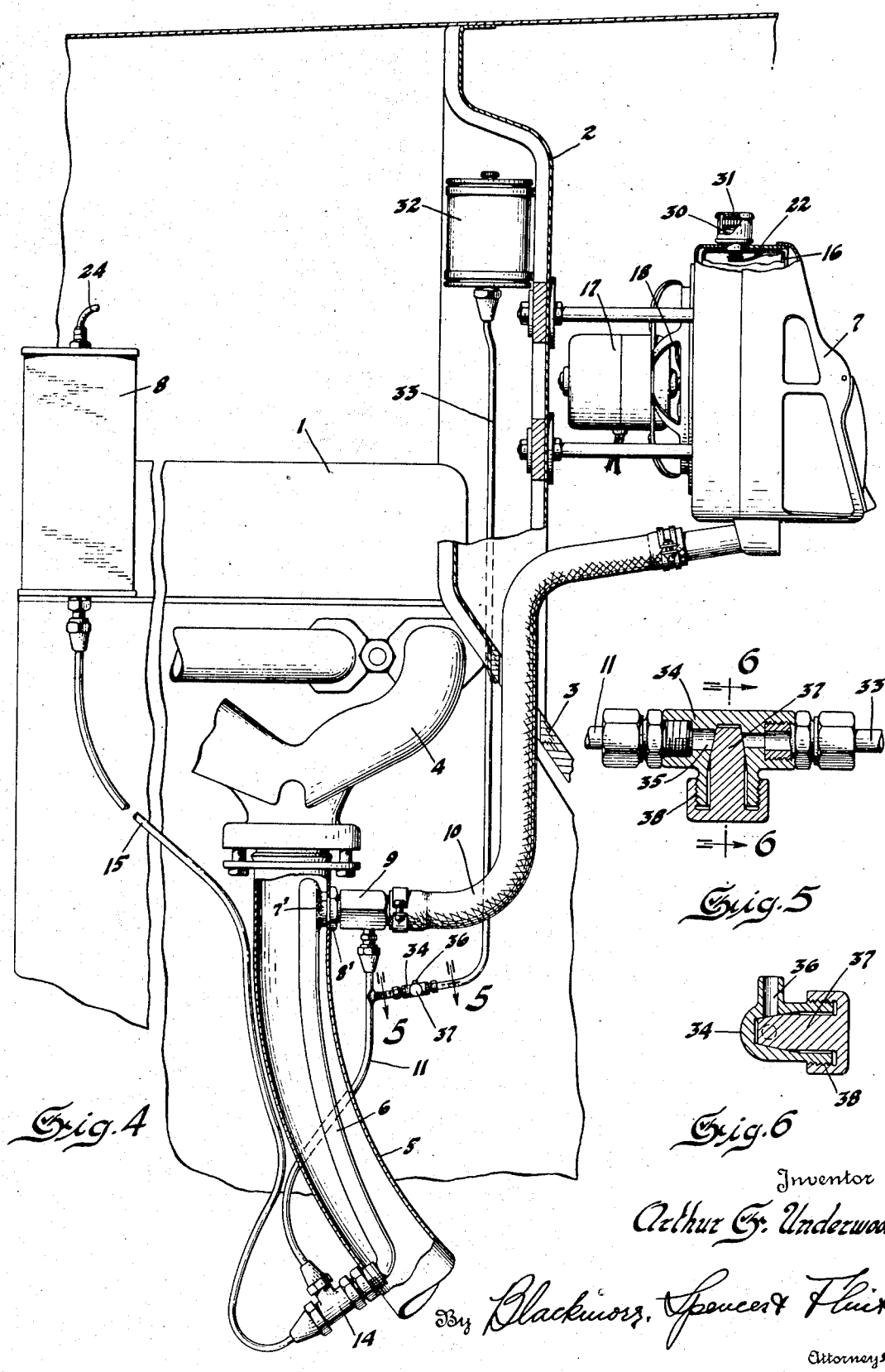


Fig. 4

Fig. 5

Fig. 6

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STEAM HEATING SYSTEM

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5 Claims. (Cl. 237—12.3)

This invention relates generally to an improved heating system, and more particularly to a heating system for motor vehicles in which the waste heat from the exhaust gases of the internal combustion engine is utilized to generate steam which is supplied to one or more radiators in the vehicle in which steam is condensed and the condensate returned to the steam generator.

One of the principal features of my invention consists in the provision of a simple control which functions to automatically regulate the quantity of steam generated by automatically varying the amount of liquid in the steam generator or boiler so as to maintain a substantially constant low pressure regardless of changes in exhaust gas temperatures which may vary from an average of 500° F. at low car speeds to 1350° F. at higher car speeds.

As will be more fully described hereinafter, this control of pressure in the system consists in the provision of a control or expansion tank which is open to the atmosphere and is positioned above and connected to the steam generator so that when any pressure is developed in the generator, liquid will be forced therefrom upwardly toward or into this tank to thereby reduce the quantity of liquid which is available in the steam generator and thereby limit the maximum in pressure which may be developed anywhere in the system so that it will never exceed that pressure required to raise the liquid from the generator to the expansion tank.

Other features of my invention and the particular advantages of the same will appear from the following detailed description of the structure and operation of the embodiments illustrated in the accompanying drawings, in which:

Figure 1 is a side elevation with parts in section of one embodiment of my heating system as applied to an automotive vehicle.

Figure 2 is an enlarged vertical sectional view taken on the line 2—2 of Figure 1.

Figure 3 is a side elevation partly in section of the expansion tank and condenser taken on line 3—3 of Figure 1.

Figure 4 is a side elevation similar to Figure 1 but illustrating a further embodiment of my heating system.

Figure 5 is an enlarged horizontal sectional view taken on the line 5—5 of Figure 4.

Figure 6 is a sectional view taken on line 6—6 of Figure 5.

Referring first to both Figure 1 and Figure 4, there has been shown diagrammatically only those portions of the usual automotive vehicle which are necessary for an understanding of the application of my improved heating system thereto. The internal combustion engine is indicated generally at 1 as located in the engine compartment which is separated from the body compartment by the usual dash 2 and floor board 3. This engine includes the usual exhaust manifold 4 and the usual exhaust pipe of which there is shown a portion 5. It will be understood that the engine is also provided with the usual cooling fan (not shown) and in this and other respects is generally similar to standard practice.

Referring now to the specific embodiment of my invention which has been illustrated in Figures 1, 2 and 3, the principal parts of the heating system consist of a steam generator or boiler unit 6, a heater unit indicated generally at 7 and an expansion tank and condenser unit 8.

The boiler 6 preferably consists of steel or alloy tubing which is flattened and secured within the exhaust pipe preferably beneath the point of attachment thereof to the exhaust manifold. As indicated, this portion of the exhaust pipe is generally extended vertically so that the boiler may be placed in a substantially vertical position to permit the attachment of a steam supply conduit adjacent its upper end and a condensate return conduit adjacent its lower end. To secure the boiler to the exhaust pipe and provide for the steam supply and condensate return thereto, an externally threaded fitting 7' may be welded to the boiler adjacent each end thereof and in assembly the boiler may be inserted from the upper end of the exhaust pipe and the fittings passed outwardly through holes which are provided in the exhaust pipe and then clamped thereto by means of a nut 8' externally applied to each fitting, such as is indicated with reference to the upper fitting or connection to the boiler which is located below the upper end of the boiler for a reason which will be given in the description of the operation of the entire system.

The upper fitting of the boiler is provided with a metal extension 9 to which is secured at its outer end a section of rubber hose 10 which functions both as a steam supply and condensate return conduit. Intermediate its ends the extension 9 is connected to a separate condensate return conduit 11 which extends downwardly to be connected with the lower end of the boiler. Within the extension 9 there is a short section of metal tubing 12 extending from the fitting to a point beyond the connection to the return conduit 11 so as to admit the steam supply to the

common conduit 10 at a point beyond the separate return conduit for the condensate, and to further prevent the steam from interfering with the return of condensate, the tube 12 is shown as located above the center of both the boiler fitting 7' and the extension 9. For convenience the filling the system with only a predetermined amount of liquid, there is provided a removable filling cap or plug 13 adjacent the upper end of the separate return conduit 11.

The lower fitting of the boiler has not been shown in detail but it should be noted that the lower end of the boiler and the fitting or extension 14 thereof is inclined downwardly and the return conduit 11 is connected thereto adjacent the boiler at a point intermediate the boiler and the connection of the fitting or extension 14 to the control conduit 15 leading to the expansion tank and condenser unit 8.

The heater unit 7 has been shown as generally similar to units now used in hot water car heater systems, being mounted on the dash 2 within the body compartment and consisting of a radiator 16 with an electric motor 17 and fan 18 for creating a forced circulation of air through the radiator. It will be readily understood that this particular type of heating unit is not an essential feature of my heating system but any known type of radiator unit may be employed and located either within the body compartment or outside of the same with suitable distributing ducts for the heated air, and with or without forced circulation.

In the type of heater unit which has been illustrated, any conventional radiator core may be used, but preferably one in which the passages are of fairly low restriction, since the condensate must run downwardly through the same passages through which the steam rises to the top of the radiator. As clearly indicated in Figure 1, the steam supply and condensate return conduit 10 is connected to the lower end of the radiator 16 and the radiator is provided at its upper end with an opening 19 which in the embodiment of my invention illustrated in Figures 1 to 3 is connected to the expansion tank and condenser unit 8 by conduit 20.

Within the upper end of the radiator is a thermostatically operated valve to substantially close the opening 19 when the radiator becomes filled with steam. This valve is shown in Figure 2 as consisting of a flat disc 21 mounted beneath the opening 19 on the free end of a bi-metal arm 22 constituted by strips of metal of such different characteristics of expansion that the disc 21 will move to substantially close the opening 19 at a temperature within the radiator of approximately 210° F. This valve has been described as substantially closing the opening in the upper end of the radiator, since there is some small leakage past the type of valve illustrated which has a definite function which will be noted hereinafter in the description of the operation of the entire system.

The expansion tank and condenser unit 8 is shown in Figure 3 as consisting of the tank 21' and superposed condenser 22' within the casing 23. The condenser may comprise merely a small section of radiator core open at its bottom to the tank 21' and opening at its top to the atmosphere through the casing 23 by means of the bent tube 24. As shown in Figures 1 and 3, the fluid control conduit 15 from the boiler is connected to the bottom of the tank 21' and the conduit 20 from the radiator is connected to the tank 21' adjacent its bottom.

In describing the operation of the embodiment shown in Figures 1 to 3, it is desired to first call attention to the location of the separate return conduit 11 and the lower portion of the conduit 15 as adjacent to each other and to the exhaust pipe 5, and also to the relative location of the radiator unit 7 and expansion tank and condenser unit 8 horizontally above the boiler 6 so that complete drainage will be afforded to the latter. It is also preferable to position the expansion tank and condenser unit 8 adjacent the forward end of the engine 1 in proximity to the usual engine cooling fan (not shown) so that such unit will be cooled by the circulation of engine cooling air.

It has been found that water is preferably the best medium for producing steam, and in view of certain disadvantages which accompany the use of anti-freezing solutions, the present system has been so designed as to prevent injury and operate properly even though freezing of the water should occur during periods in which the heating system is not in use, or in other words, when the engine is not in operation. Let us assume, for instance, that the heating system has just been installed. The filling plug 13 would be removed and an amount of water introduced until over-flow occurs through the filling opening which would thereafter be closed by the filling plug. It will be noted that this filling plug opening is so located that the maximum amount of water which may be introduced into the system will be contained within the major portion of the boiler within the exhaust pipe and those portions of the conduits 11 and 15 which are adjacent the exhaust pipe 5. Therefore, if this liquid freezes, it may expand slightly without injury to the system and whenever the engine is started the hot exhaust gases will soon thaw out the entire body of liquid.

In normal operation, when the engine is started, the hot exhaust gases coming into contact with the boiler surface heats the liquid in the boiler forming steam which passes through the steam supply conduit 10 to the radiator 16, where it is condensed by heat radiation which is facilitated by the air circulating fan. This condensate returns through the conduit 10 to the over-flow pool formed within the extension 9 from where it is returned to the bottom of the boiler through the return conduit 11.

The boiler 6 is constructed of a substantially vertical tube which has a sufficiently large passage when flattened to afford the minimum restriction, since if too restrictive, the sudden formation of steam at the entering point will push the incoming liquid from the boiler instead of pushing the steam to the heater unit. Also the steam outlet is located several inches from the top of the boiler so that any liquid which might be forced to the top of the boiler by rapid steam formation will not pass into the steam supply conduit but will be turned into steam or fall back to the lower part of the boiler.

As the radiator 16 first becomes filled with steam, the air within the radiator is forced through the conduit 20 and expelled through the tank 21' and condenser 22' to the atmosphere. When substantially all air has been expelled, contact of the steam with the bi-metal arm 22 substantially closes the opening 19 in the upper end of the radiator to prevent the escape of substantially all of the steam vapor in the radiator.

As was noted in the description of the thermostatically operated valve, the same permits some slight leakage. This prevents the valve from retaining in the radiator such gas (as distinguished from steam) which may be generated in the system. It has been found by actual experiment that even when using water with no anti-freeze solution, a fixed gas was generated at high speeds or high exhaust gas temperatures, and that this gas would rise to the top of the radiator and gradually decrease the steam capacity sufficiently to seriously interfere with the heat radiation from the radiator, making it necessary to provide some means for escape of this gas. In addition to possible impurities in the water to produce this gas, it has been primarily thought to be formed by liberation of hydrogen by the reaction of the water with the iron of the boiler at high temperatures. Regardless of the real source of this fixed gas, it will be apparent that the provision of some leakage past the thermostatic valve in the upper end of the radiator permits this gas to escape to the atmosphere through the condenser 22' which prevents such small amount of steam as might also escape past the thermostatic valve from being lost with consequent reduction in the amount of liquid which would require the addition of more liquid at indeterminate intervals.

It will be obvious that with the exhaust temperatures which are available for steam generation, more steam will be generated than can be condensed in the radiator and the expansion tank and condenser unit 8 is therefore connected to the bottom of the boiler by the conduit 15 so that the liquid level within the boiler will be lowered automatically on the generation of any pressure within the upper end of the boiler by forcing the liquid from the bottom of the boiler upwardly toward or into the expansion tank, and at high engine speeds, it will be found that there is very little liquid in the boiler and most of it will be in the expansion tank. Also it will be readily seen that when the radiator is completely filled with steam, a pressure will be maintained which is equal to the head of liquid within the expansion tank and the conduit from the same to the boiler. It will also be obvious that whenever the pressure falls below this maximum, liquid will be returned to the boiler from the expansion tank and its connecting conduit and a point of pressure equilibrium will be almost constantly maintained.

In addition to preventing the escape of any steam vapors which may leak past the thermostatically operated valve in the radiator, the condenser 22' is provided above the expansion tank 21' to prevent the loss of any vapors which may be given off by the liquid within this tank, and as has been noted hereabove, the efficiency of the condenser is preferably increased by locating the same adjacent the engine cooling fan. Ordinarily, the liquid in the expansion tank is at a sufficiently low temperature that no vapors would be produced therein, but if the engine is first started at high speeds, substantially all of the liquid in the boiler would be heated and on generation of steam, a large proportion of this heated liquid would be suddenly forced to the expansion tank. Under these conditions, however, the condenser would function to substantially entirely prevent vapor loss. The escape of vapor is further prevented or reduced by returning the highly heated condensate from the radiator to the boiler at a point between the boiler and the connection to the conduit to the expansion tank below the lowermost end of the boiler.

Referring now to the embodiment illustrated in Figures 4, 5 and 6, the construction and operation thereof is similar to the embodiment of Figures 1, 2 and 3 except for the elimination of the vent conduit from the upper end of the radiator to the expansion tank and condenser unit and the provision of a small leakage tank 30 and condenser 31 mounted directly on the top of the heater unit 7. There has also been provided an accessory reserve tank 32 to facilitate filling or replenishing the supply of liquid in the system.

With reference to the small leakage tank 30 and condenser 31, which is open to the atmosphere, the same functions in conjunction with the thermostatically operated valve within the upper end of the radiator to provide for the escape of air from the radiator until the latter becomes filled with steam and thereafter functions to receive and condense such small leakage as there may be past the thermostatically operated valve and permits the escape of any gas which may be generated in the system. Such steam vapors as may leak past the thermostatically operated valve and be condensed by the small condenser 31 will be retained in the leakage tank 30 and returned to the system whenever the upper end of the radiator cools sufficiently to permit any substantial opening of the thermostatically operated valve.

The reserve tank 32 is preferably located on the dash within the engine compartment and is connected to the system by conduit 33 at a point in the condensate return conduit 11 corresponding to the location of the filling opening and plug in the embodiment of my invention shown in Figure 1. A valve unit 34 is provided in the conduit 33 adjacent the connection to conduit 11. This valve unit 34, as shown in detail in Figures 5 and 6, includes in addition to the liquid passage 35 leading to the conduit 11, a further passage 36 opening to the atmosphere. Both the passage 35 and the passage 36 are adapted to be opened simultaneously by manual rotation of the plug valve 37 which is screw-threaded on the valve unit as at 38. As will be apparent, when the valve is operated to admit liquid to the system, the liquid will run out of the passage 36 as soon as the system becomes filled to the proper level.

It should be understood that the accessory reserve tank and filling valve illustrated in the system of Figure 4 could of course be substituted for the filling opening and plug in the system of Figure 1, and vice-versa. If a reserve tank is employed, it would no doubt be necessary to employ some anti-freeze solution therein, but after introduction of this solution to the heating system, any gas caused by decomposition and which might eventually interfere with proper operation of the system by restricting the heating capacity of the radiator would not be retained in the system but would be exhausted by leakage through the expansion tank and condenser unit of Figure 1 or the small leakage tank and condenser unit of Figure 4.

No means has been provided in either of the illustrated systems to entirely stop operation thereof, since this is considered unnecesary with the type of heating unit shown in which substantially no heat is dissipated by the radiator without the forced air circulation afforded by the fan which may be turned off or its speed regulated in accordance with usual practice. If found desirable, however, with this or other types of heating

units, a manually operable shut-off valve could be provided and located, for instance, in the steam supply and condensate return conduit.

From the above detailed description, it will be seen that a very simple and yet highly effective heating system has been provided which has been illustrated as particularly adapted for motor vehicles. My invention, however, is not limited to use on motor vehicles which includes automobiles, buses, trucks and airplanes, but certain features therein may also be found suitable for other applications and are also not limited to use of exhaust gases of an internal combustion engine as the steam generating medium.

While in accordance with the provisions of the statutes I have illustrated and described herein two embodiments of my invention, it will be apparent that changes may be made in the form of the systems disclosed without distinguishing from the spirit of my invention as set forth in the appended claims. It will also be apparent that certain features of my invention may be used to advantage without a corresponding use of other features.

What I claim as my invention is:

1. A steam heating system for motor vehicles comprising in combination with the vehicle engine and its exhaust pipe, a radiator for the vehicle, a steam generator adapted to contain a vaporizable liquid and associated with said exhaust pipe so as to be heated by the exhaust gases passing therethrough, means connecting said generator to said radiator for the supply of steam to the radiator and the return of condensate to the generator, and means to automatically control the quantity of steam generated by automatically varying the amount of liquid in said generator comprising a vented expansion tank, means connecting said generator to said expansion tank into which liquid will be forced by steam pressure developed in said generator, said expansion tank being continuously vented to the atmosphere through an air cooled condenser to condense any vapors from the liquid in said tank and return the condensate to the system.

2. In a steam heating system, the combination with a boiler adapted to contain a vaporizable liquid and generate steam on application of heat thereto, a radiator, means connecting said boiler to said radiator for the supply of steam to the radiator and the return of condensate to the boiler, an expansion tank, means connecting said tank to said boiler to receive liquid therefrom, a vented condenser on said expansion tank to receive steam and return the condensate to the system, and means connecting said radiator to said condenser with a thermostatically operated valve in said radiator which is adapted to substantially close said connecting means to said condenser when said radiator becomes filled with steam.

3. A steam heating system for motor vehicles comprising in combination with the vehicle engine and its exhaust pipe, a radiator for the vehicle, a steam generator adapted to contain a vaporizable liquid and associated with said exhaust pipe so as to be heated by the exhaust gases passing therethrough, means connecting said generator to said radiator for the supply of steam to the radiator and the return of condensate to the generator, and means to automatically control the quantity of steam generated by automatically varying the amount of liquid in said generator, comprising an expansion tank and condenser unit connected to said generator to receive liquid therefrom, said expansion tank and condenser unit being positioned adjacent the front end of the vehicle engine so as to be cooled by the circulation of air thereover.

4. In a steam heating system, the combination with a boiler adapted to contain a vaporizable liquid and generate steam on application of heat thereto, a radiator, means connecting said boiler to said radiator for the supply of steam to the radiator and the return of condensate to the boiler, a vented expansion tank connected to said boiler, and means to supply liquid to said system comprising a separate reserve tank and means including a manually operable valve for connecting said reserve tank with said system, said valve being provided with an overflow passage which is opened to the atmosphere when said reserve tank is placed in communication with said system to limit the amount of liquid which may be supplied to said system to that which may be contained therein below the horizontal level of said valve passage.

5. In a steam heating system, the combination with a boiler adapted to contain a vaporizable liquid and generate steam on application of heat thereto, a radiator, means connecting said boiler to said radiator for the supply of steam to the radiator and the return of condensate to the boiler, a vented expansion tank so connected to said boiler as to receive liquid therefrom and automatically control the amount of liquid available for steam generation therein, a relatively restricted connection from a normal point of air accumulation in said radiator to said expansion tank, and a thermostatically operated valve in said radiator to substantially close the connection of said radiator to said expansion tank when said radiator becomes filled with steam.

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