

**Jan. 6, 1942.**

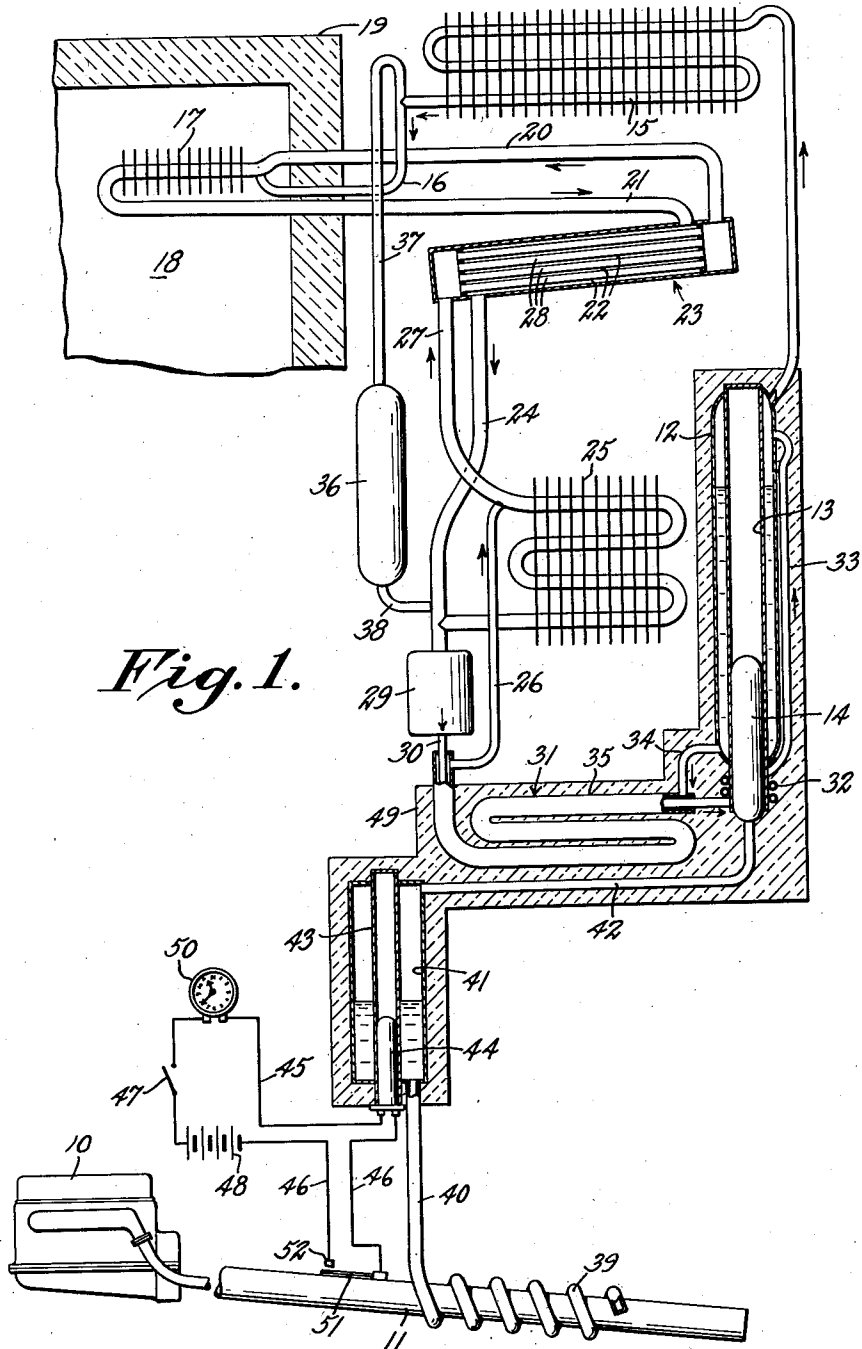
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**2,269,099**

## HEAT TRANSFER SYSTEM

Filed Oct. 23, 1936

4 Sheets-Sheet 1



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HEAT TRANSFER SYSTEM

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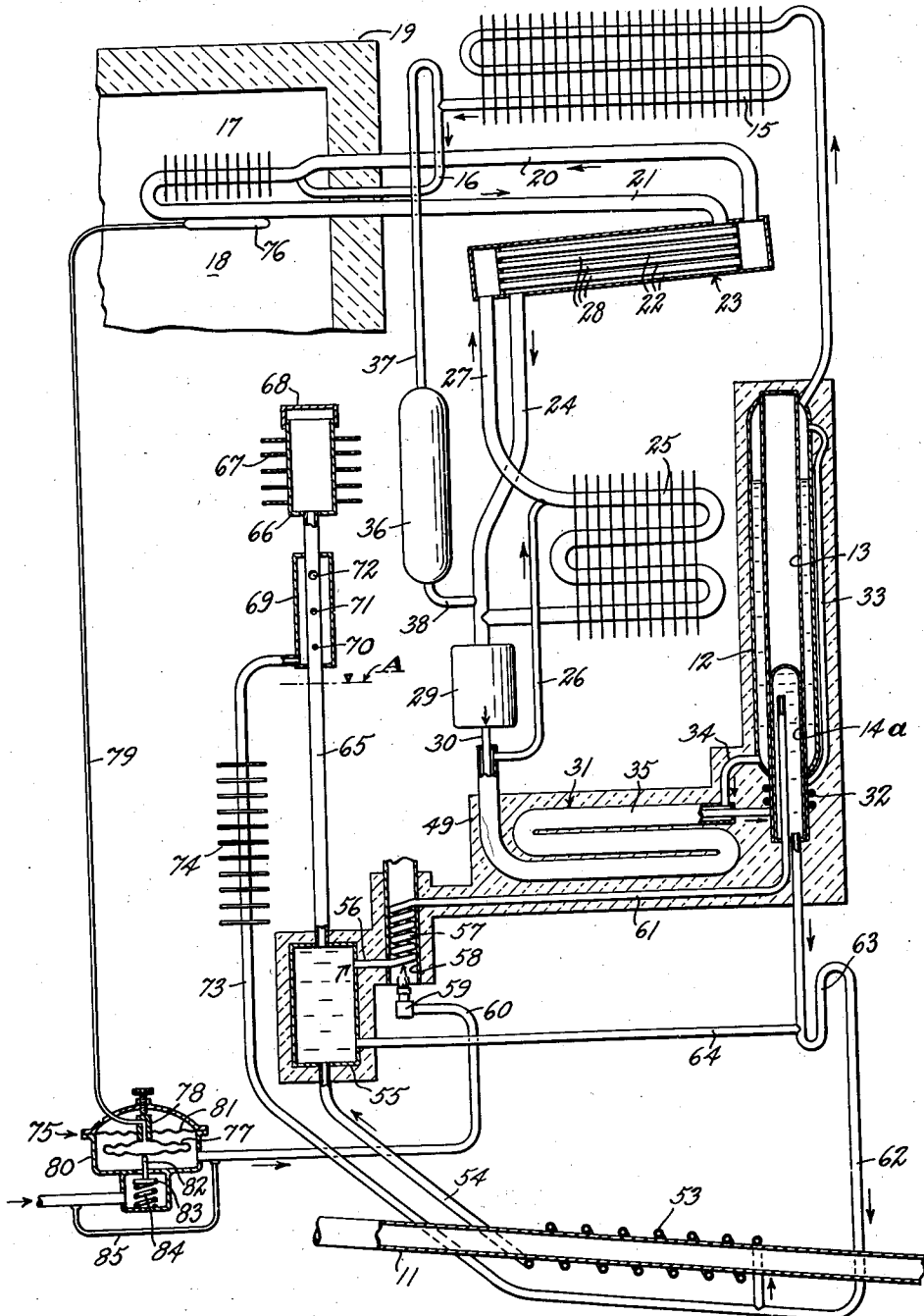


Fig. 2.

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HEAT TRANSFER SYSTEM

Filed Oct. 23, 1936

4 Sheets-Sheet 3

*Fig. 3.*

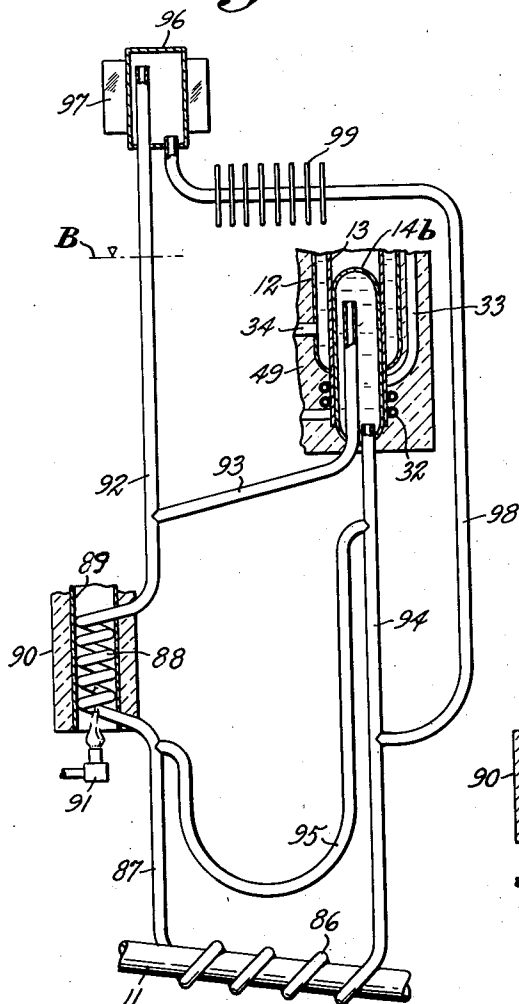
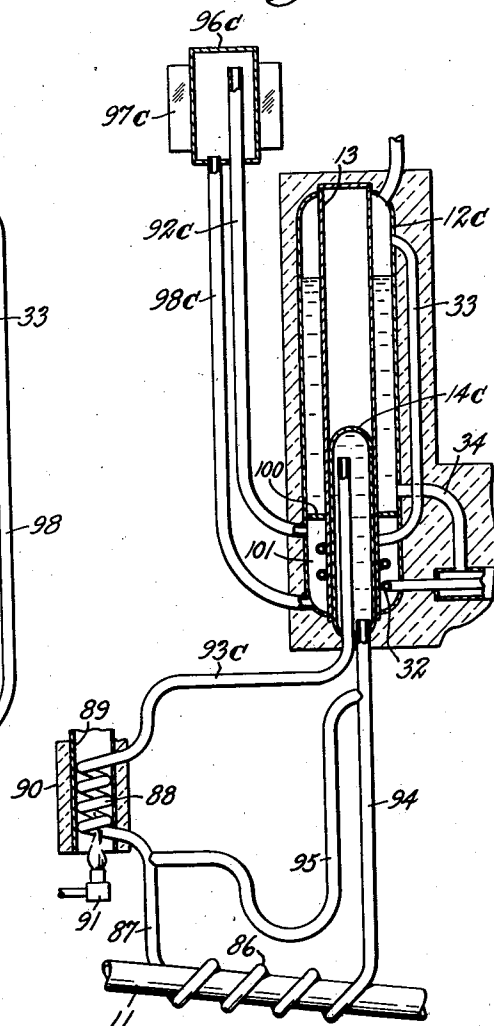


*Fig. 4.*



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4 Sheets-Sheet 4

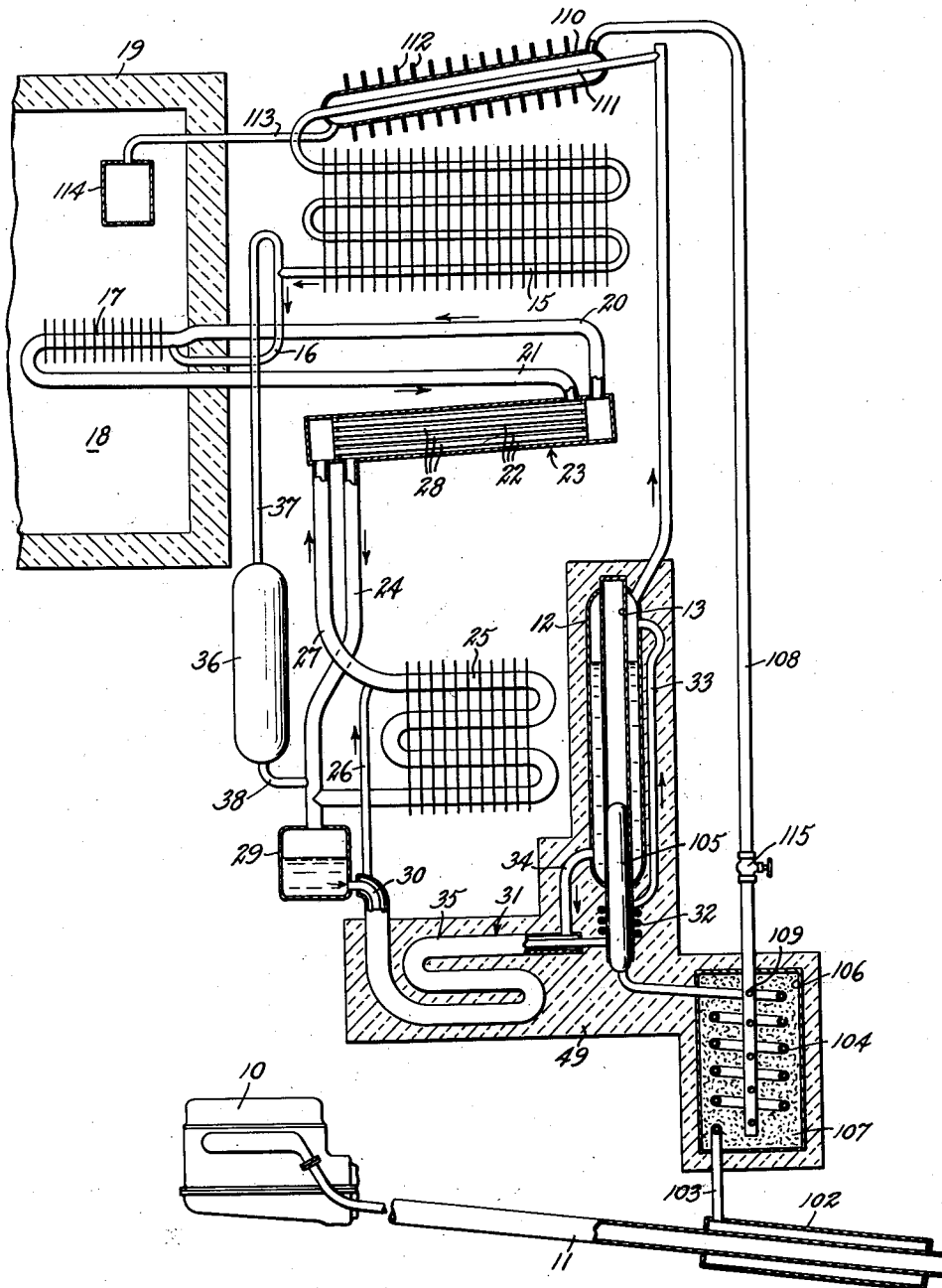


Fig. 5.

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## UNITED STATES PATENT OFFICE

2,269,099

## HEAT TRANSFER SYSTEM

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Application October 23, 1936, Serial No. 107,129  
In Germany October 26, 1935

33 Claims. (Cl. 62—5)

My invention relates to heat transfer systems, and more particularly to the art of transferring heat from an available heat source to a place of heating where it may be effectively utilized.

One of the objects of my invention is to provide an improved heat transfer system, containing a fluid for transferring heat from an available source to a place of heating, which is so constructed and arranged that heat may also be transferred from an additional source to the place of heating without disturbing the connections of the heat transfer system.

Another object of my invention is to provide an improved heat transfer system, containing a fluid for transferring heat from an available source to a place of heating, which is so constructed and arranged that energy derived from the available source may be stored and such stored energy may be utilized as the additional source of heat.

A further object of my invention is to provide an improved heat transfer system for transferring heat from a suitable source to a place of heating in which the quantity of heat so transferred may be controlled automatically without valves and independently of the source of heat.

A still further object of my invention is to provide a fluid heat transfer system in which the quantity of heat transferred from a suitable source to the place of heating is controlled by normally circulating the fluid in one portion of the system to transmit heat to the place of heating and causing the same or different fluid to circulate in another portion of the system upon a definite increase in temperature of the source of heat whereby surplus heat produced at the source is transmitted to an element in the other portion of the system.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the claims. The invention itself, however, both as to organization and method, together with further objects and advantages thereof, will be better understood by reference to the following description taken in connection with the accompanying drawings in which Fig. 1 diagrammatically illustrates an embodiment of my invention for transferring the heat of exhaust gases of an internal combustion engine to refrigeration apparatus operated by heat and for also transferring to such apparatus heat from an electrical heating element which is utilized as an additional heat source; Fig. 2 is a modification of the embodiment shown in Fig. 1 wherein a gas burner is utilized as the additional

heat source and provision is also made for automatically controlling the quantity of heat transferred to the refrigeration apparatus; Figs. 3 and 4 are fragmentary views diagrammatically illustrating modifications of the embodiment shown in Fig. 2; and Fig. 5 diagrammatically illustrates a further modification of the embodiment shown in Fig. 1 in which intermittent refrigeration apparatus having a generator-absorber in thermal relation with the heat transfer system is employed to store energy derived from the heat of the exhaust gases and such stored energy is utilized as the additional source of heat.

In accordance with my invention I provide an improved system containing a fluid for transferring heat to a place of heating from an available heat source. Although not to be limited thereto, my invention has a particular application for the effective utilization of waste heat from any available or primary heat source, such as, for example, waste heat of exhaust gases of internal combustion engines, furnaces, stoves, or heating plants. The heat transfer system preferably is so constructed and arranged that heat may also be transferred from an additional heat source to the place of heating without disturbing the connections of the heat transfer system. The place of heating may be any suitable apparatus, such as, for example, a hot water heater, refrigeration apparatus operated by heat, room heaters, or the like.

Referring to Fig. 1, I have shown my invention in connection with an internal combustion engine 10 wherein the heat of the exhaust gases discharged therefrom through a pipe 11 is transferred to a place of heating such as, for example, generator 12 of absorption refrigeration apparatus. The refrigeration apparatus I have shown is of a well-known uniform pressure absorption type in which an auxiliary pressure equalizing gas is employed. It is to be understood, however, that my invention can be employed with other types of refrigeration apparatus operated by heat.

The refrigeration apparatus includes the generator 12 containing a refrigerant in solution in an absorption liquid, and, although I do not wish to be limited thereto, the refrigerant may be ammonia and the absorption liquid may be water. The generator 12 is provided with an annular sleeve 13 which is closed at its upper end and within the lower end of which is arranged a heating element 14 forming part of my heat transfer system, hereinafter to be described.

The heat applied to the generator 12 and its contents expels the ammonia out of solution and such ammonia flows upward to an air-cooled condenser 15. The ammonia is liquefied in the condenser 15 and flows through a conduit 16 to the upper end of an evaporator coil 17 which serves as a cooling element and is arranged within the storage compartment 18 of a refrigerator cabinet 19. An inert gas, such as hydrogen, enters the upper end of the evaporator coil 17 from a conduit 20. The hydrogen and ammonia flow in the same direction in the presence of each other, and the ammonia evaporates and diffuses into the hydrogen with consequent absorption of heat from the surroundings of the cooling element. The resulting gas mixture of ammonia and hydrogen flows from the evaporator coil 17 through conduit 21, the outer passage 22 of a gas heat exchanger 23, and vertically extending conduit 24 which communicates at its lower end with the lower part of an air-cooled absorber 25.

In the absorber 25 the ammonia is absorbed out of the gas mixture into weak absorption liquid which enters the upper part of the absorber through a vertically extending conduit 26. The hydrogen, which is practically insoluble and weak in ammonia, passes upward from the absorber 25 through conduit 27, a plurality of parallel tubes 28 which form the inner passage of the gas heat exchanger 23, and conduit 20 to the upper end of the evaporator coil 17. The gas heat exchanger 23 transfers heat from gas weak in ammonia which is flowing to the evaporator coil 17 to gas rich in ammonia which is flowing to the absorber.

The absorption liquid flowing downward through the absorber 25 in counter-flow to the gas mixture becomes enriched in ammonia and passes through the lower end of conduit 24 to a vessel 29 which serves as an accumulation vessel for the absorption liquid. From the vessel 29 strong absorption liquid flows through the inner conduit 30 of a liquid heat exchanger 31 to a coil 32 disposed about the lower end of the sleeve 13. The rich absorption liquid is raised by vapor-lift action from the coil 32 through conduit 33 into the upper part of the generator 12. The liquid is raised to a higher level in the generator 12 than it is in the absorber 25, and absorption liquid weak in ammonia flows from the lower part of the generator through conduit 34, outer conduit 35 of the liquid heat exchanger 31, and conduit 26 into the upper part of absorber 25.

In order to vary the total pressure in the refrigeration system just described with changes in air temperature, a vessel 36 is provided with the upper part thereof connected by a conduit 37 to the lower end of the condenser 15 and the lower part thereof connected by a conduit 38 to conduit 24 of the gas circuit. The vessel 36 and conduits 37 and 38 provide a path of flow from the condenser 15 to the gas circuit, so that any hydrogen which passes through the condenser can flow to the gas circuit and not be trapped in the condenser. Further, should the air temperature increase so that ammonia is not liquefied in the condenser, the ammonia vapor will flow through conduit 37 to displace hydrogen in the vessel 36 and force such hydrogen through conduit 38 into the gas circuit. This raises the total pressure in the system so that an adequate condensing pressure results for the increased air temperature.

In accordance with my invention the heat transfer system for transferring heat of the ex-

haust gases of the engine 10 to the refrigeration apparatus includes an evaporation member 39 which is in the form of a helical conduit disposed about and in good thermal contact with the pipe 11. The evaporation member 39 is closed at one end and its other end is connected by a conduit 40 to the lower part of a vessel 41, the upper part of which is connected by a conduit 42 to the condenser member 14 which serves as the heating element of the generator 12. The vessel 41 is provided with an annular sleeve 43 which is closed at its upper end and within the lower end of which is arranged an electrical heating element 44 which is connected by conductors 45 and 46 and a switch 47 to a suitable source of electrical energy indicated at 48. The generator 12, liquid heat exchanger 31, and vessel 41 may, if desired, be arranged within a body 49 of suitable insulating material. The evaporation member 39, vessel 41, condenser member 14, and conduits 40 and 42 form a hermetically sealed circuit adapted to contain a suitable fluid, such as water, for example, to the level shown in Fig. 1.

When the internal combustion engine 10 is being operated, the liquid in the member 39 is evaporated due to the high temperature of the exhaust gases discharged through the exhaust pipe 11. The vapor passes upward through conduit 40, vessel 41, and conduit 42 into the member 14 in which it is condensed. The water condensed in the member 14 flows downward through conduit 42 and is again evaporated. It will therefore be understood that an evaporation-condensation circuit has been provided in which the fluid serves as a heat transfer agent which circulates naturally in the closed fluid system. The evaporation of the liquid in the member 39 takes up heat from the exhaust gases discharged through the pipe 11, and the condensation of the vapor in the member 14 gives up heat to the generator 12 and its contents to expel refrigerant out of solution from the absorption liquid, whereby refrigeration is produced in the storage compartment 18 to maintain the latter at a desired low temperature.

In many instances it may be desirable to maintain the storage compartment 18 at a desired low temperature even when the internal combustion engine 10 is not being operated. This is particularly true when the engine 10 is employed to propel a motor vehicle and the refrigerator cabinet 19 is mounted on the vehicle. In such case, it is imperative at times to maintain the storage compartment 18 at a desired low temperature when the engine 10 is not being operated, especially when the refrigerator cabinet 19 is loaded with merchandise. To maintain the storage compartment 18 at a desired low temperature when the engine 10 is not being operated the switch 47 is closed whereby the electrical heating element 44 becomes effective to evaporate liquid in the vessel 41. The vapor formed in the vessel 41 passes through conduit 42 into the member 14 in which it is condensed and flows downward to the vessel 41 and is again evaporated. In this manner the liquid in the upper part of the heat transfer system is effectively utilized to transfer heat from the additional or secondary heat source 44 to the member 14 for heating the generator 12. While the fluid in the upper part of the heat transfer system serves to transfer heat from the additional heat source 44 to the generator 12, practically no heat is transferred from

the vessel 41 to the liquid in member 39 due to the fact that the additional heat source 44 is arranged at a higher point than the exhaust pipe 11. The amount of heat transferred downward from the vessel 41 to the member 39 through the walls of conduit 40 and the body of liquid may be made almost negligible by suitable insulation and proper dimensioning of these parts of the heat transfer system.

By employing a heat transfer system of the character just described in which a secondary heat source may be utilized in addition to the primary heat source, a system is provided which may be permanently installed between an available heat source and a place of heating without the necessity of removing one condenser member and providing a secondary source of heat. This is particularly advantageous in instances in which the condenser member or heating element must assume a particular form to heat a very limited part of the apparatus, such as the refrigeration apparatus shown, to which it is desired to transfer heat.

It has been stated above that when the engine 10 is employed to propel a motor vehicle and the refrigerator cabinet 19 is mounted on the vehicle, it may be desirable to maintain the storage compartment 18 at the desired temperature even when the engine is not being operated. Thus, at a particular time it may be necessary to have the storage compartment at a desired low temperature when merchandise is being loaded in the refrigerator cabinet 19. In order to avoid operating the engine 10 for a relatively long period of time before the vehicle is to be driven, the switch 47 may be closed whereby the secondary heat source 44 becomes effective to cause the fluid in the heat transfer system to transfer heat to the generator 12. In this manner the storage compartment 18 is at the desired low temperature at the time the cabinet 19 is to be loaded with merchandise without any necessity of operating the engine 10. When the vehicle is ready to be driven the switch 47 is opened and the exhaust gases of the engine are utilized to heat the generator 12 of the refrigeration apparatus. Since the volumetric capacity of the evaporation member 39 is relatively small the liquid therein is heated rapidly and becomes effective to transfer heat to the generator 12 so that the production of cold in the storage compartment 18 is not interrupted.

When it is desired to have the storage compartment 18 at a low temperature at a particular time, automatic mechanism may be provided whereby the secondary heat source becomes effective to evaporate liquid in the vessel 41 at a designated time so that the storage compartment 18 is at the desired low temperature when the refrigerator cabinet 19 is loaded with merchandise. Such automatic mechanism may comprise a control clock, diagrammatically indicated at 50 in Fig. 1, which may be connected in the conductor 45 and operative to complete the electrical circuit of the heating element 44 at a particular set time.

The amount of liquid used is considerably less than the volumetric capacity of the circuit, and, when using water, it is preferably about one-third of the volumetric capacity. In such case a temperature of about 300° C. is readily maintained in the condenser 14 to heat the generator 12 and its contents. It should be understood, however, that other fluids may be used in the

evaporation-condensation circuit, such as toluene, for example, having critical pressures and other physical characteristics which are capable of maintaining the condenser member at the desired temperature for any particular installation.

In order that the secondary heat source 44 is automatically effective to continue the heating of the generator 12 when the operation of the engine 10 is stopped, a suitable thermostat responsive to the temperature of the exhaust gases, such as the bi-metallic thermostat diagrammatically shown in Fig. 1, may be connected in the conductor 46. When the operation of the engine 10 is stopped the bi-metallic strip 51, which is normally separated from the contact 52 during operation of the engine, flexes upward to complete the circuit of the electrical heating element 44 whereby the production of cold is not interrupted even though the engine is not being operated.

In Fig. 2 I have shown a modification which differs from the embodiment just described in that the transfer of heat in the heat transfer system is effected primarily by the circulation of liquid therein. The refrigeration apparatus illustrated in Fig. 2 is similar to that shown in Fig. 1 with like parts indicated by the same reference numerals. The heat transfer system shown in Fig. 2 includes a member 53 in the form of a helical conduit which is in heat exchange relation with the pipe 11 through which pass the high temperature exhaust gases discharged from an internal combustion engine (not shown). The upper end of the member 53 is connected by a conduit 54 to the lower part of a vessel 55, the upper part of which is connected by a conduit 56 to the lower end of a coil 57 which is arranged within a flue 58 which may, if desired, be disposed in the body 49 of insulating material. The coil 57 is adapted to be heated by a gaseous or liquid fuel burner 59 which serves as the secondary heat source and to which fuel is conducted through a conduit 60 from a suitable source of supply.

The upper end of the coil 57 is connected to a conduit 61 which extends into the upper part of a member 14a which is similar to the condenser member 14 in Fig. 1. From the lower part of the member 14a depends a conduit 62 which is provided with an S-shaped bend intermediate its ends and the lower end of which is connected to one end of the member 53. The vessel 55 and conduit 62 are connected by a conduit 64 which serves as a by-pass for liquid in the system during the periods the secondary heat source 59 is utilized to heat the generator 12, as described hereinafter.

To the upper part of the vessel 55 is connected a vertical conduit 65 which is connected to the lower end of a vessel 66 which is provided with a plurality of cooling fins 67 and may be closed by a removable air-tight cover 68. Below the vessel 66 the conduit 65 is provided with a jacket 69 which encloses a portion of the conduit having three openings 70, 71, and 72 which are successively larger with the top opening 72 being the largest. The lower part of the jacket 69 is connected by a conduit 73 to the lower end of the member 53 and preferably is provided with a plurality of cooling fins 74.

The heat transfer system is preferably filled with a liquid which has a relatively high boiling point, such as oil, to the level indicated at A in

conduit 65. When the internal combustion engine is being operated, the liquid in the member 53 is heated due to the high temperature of the exhaust gases passing through the pipe 11. The specific gravity of the liquid heated in the member 53 is reduced and such heated liquid passes upward in the direction indicated by the arrows through the vessel 55, coil 57, and conduit 61 into the member 14a in which it is cooled. The specific gravity of the liquid is increased due to such cooling and flows downward through the conduit 62 to the member 53 in which it is again heated. The liquid in the member 53 takes up heat from the exhaust gases, and the liquid cooled in the member 14a gives up heat to the generator 12 and its contents whereby refrigeration is produced in the storage compartment 18. It will therefore be understood that a heat transfer system has been provided in which liquid circulates naturally due to force produced by the difference in specific gravity of the liquid in two portions of the system, whereby heat is effectively transferred from the exhaust gases to the refrigeration apparatus. The difference in specific gravity of the liquid in the two portions of the system is not only due to the difference in temperatures of the upward and downward flowing liquid but also due to the vapor bubbles which are formed in the member 53 and pass upward through the vessel 55, coil 57, and conduit 61 into the member 14 in which they are condensed.

To maintain the storage compartment 18 at a desired low temperature when the engine is not being operated the secondary heat source 59 may be utilized to cause circulation of liquid in the system and thereby transfer heat to the refrigeration apparatus. When the liquid in the coil 57 is heated by the burner 59 liquid circulation in the manner described above takes place through a smaller cycle from the coil 57 and conduit 61 to the member 14a. The liquid cooled in the member 14a passes downward through the upper part of conduit 62, conduit 64, and vessel 55 back to the coil 57 in which it is again heated. Substantially no movement of liquid takes place in the lower part of conduit 62, member 53, and conduit 54 during heating only by the secondary heat source 59. By providing the S-shaped loop 63 in the conduit 62 at the point the conduit 64 is connected thereto, the tendency of liquid to circulate in the lower part of the system is reduced considerably whereby excessive heat loss to the pipe 11 is avoided during the periods the engine is not being operated and the exhaust pipe 11 is cold. As in the embodiment illustrated in Fig. 1, suitable mechanism may be provided for rendering the secondary heat source 59 automatically operative when the engine 10 is not being operated.

If desired, the secondary heat source may be rendered operative in response to a temperature condition affected by the cooling element 17. This may be accomplished by providing an expansible fluid thermostat for controlling a valve 75 connected in the conduit 60. The expansible fluid thermostat contains a volatile fluid and comprises a bulb 76 which may be secured to and in thermal contact with the cooling element 17, an expansible diaphragm 77 communicating with and secured to a hollow member 78, and a conduit 79 connecting the bulb 76 and hollow member 78. The expansible diaphragm 77 and hollow member 78 are arranged to be supported within casing 80 by a resilient diaphragm 81 to

which the hollow member 78 is secured. The expansible diaphragm 77 contacts stem 82 of valve 83 which is urged toward its closed position by a resilient spring 84.

When the cooling element 17 tends to rise above the desired low temperature due to the stopping of the internal combustion engine, the expansible fluid thermostat causes the expansible diaphragm 77 to expand and move the valve 83 downward against the tension of spring 84 to permit normal flow of gas to the burner 59. When the cooling element tends to remain at or below the desired low temperature during the periods the internal combustion engine is being operated, the expansible fluid thermostat causes the expansible diaphragm 77 to contract and permit the valve 83 to be urged toward its closed position to decrease the flow of gas to the burner 59. A small by-pass conduit 85 may be connected around the control valve 75 to permit the flow of a small quantity of gas to maintain a pilot or ignition flame at the burner 59.

The liquids preferably used in the heat transfer system are those having a high boiling point so that under normal operating conditions the liquid circulates naturally within the system to transfer heat from the heat source to the place of heating without any boiling of the liquid. In accordance with my invention the system shown in Fig. 2 is so constructed and arranged that the quantity of heat transferred from the high temperature exhaust gases or secondary heat source 59 is automatically controlled without valves and independently of the heat source.

When the engine is first started the system is filled with liquid to the level indicated at A in the conduit 65. If it is assumed that the heat transfer system causes the temperature in the member 14a to increase to 200° C., for example, the mean temperature of liquid in the system is increased considerably thereby increasing the volume of the body of liquid. This may cause the liquid level in the conduit 65 to rise from its original level to the position of the opening 70, for example. A decided rise in the level of liquid in the conduit 65 can be readily obtained by making the conduits 65 and 73 relatively small in size and using a relatively large quantity of liquid in the heat transfer system. If it is assumed that the temperature of the liquid has increased sufficiently to cause liquid in the conduit 65 to rise to the level of the opening 70, liquid flows into the jacket 69 and downward in conduit 73 whereby circulation of liquid is started in an additional portion of the system including the member 53, conduit 64, vessel 55, conduit 65, jacket 69, and conduit 73. The heated liquid flowing from the conduit 65 into the jacket 69 is cooled in conduit 73, the cooling fins 74 being provided to facilitate the transfer of heat to the surrounding cooler air.

As the temperature of the liquid in the heat transfer system increases the level of liquid in conduit 65 rises and passes through the larger openings 71 and 72 whereby the quantity of liquid circulating in the additional circuit of the system increases to increase the quantity of surplus heat transferred from the heat source to the conduit 73. When the temperature of the liquid in the system decreases due to such transfer of surplus heat in the additional circuit, the volume of liquid decreases and the liquid level in the conduit 65 becomes lower whereby the extent of liquid circulation effected in the additional circuit is decreased. It will therefore be

understood that liquid normally circulates through one portion of the system to transfer heat from a heat source to a place of heating, and that upon a definite increase in temperature of the heat source liquid circulates through another portion of the system to transfer surplus heat from the heat source to a medium in thermal relation with the other portion of the system.

The automatic control of the quantity of heat transferred to the place of heating is also obtained when only the secondary heat source 59 is employed. In such case the level of liquid in the conduit 65 increases upon a definite increase in temperature of the liquid inasmuch as the main quantity of liquid is contained in the portion of the system through which the liquid circulates due to the heating thereof by the secondary heat source.

The vessel 66 may contain a suitable neutral gas, such as air, for example, which can be maintained at any desired pressure to increase the boiling point of the liquid in the system to such an extent that no boiling will take place. If desired, the cover 68 may be removed from the vessel 66 whereby the boiling point of the liquid in the system is accurately determined. If it is assumed that the boiling point of the liquid is 300° C., for example, and the vessel 66 is open to the atmosphere and sufficiently large so that effective cooling is obtained in the vessel, the temperature of the member 14a will not rise above 300° C. By making the vessel 66 sufficiently large and providing the vessel with cooling fins 67 to facilitate the transfer of heat from the liquid to the surrounding cooler air, the evaporation of liquid in the vessel 66 is relatively small and practically negligible. When the heat transfer system is employed with the vessel 66 open to the atmosphere to transmit surplus heat from the heat source in a manner just described, the local circulation of liquid in conduit 65 and vessel 66 may alone be utilized to automatically control the quantity of heat transferred from the heat source to the place of heating without employing the conduit 73 to provide an additional circuit for the liquid.

Fig. 3 illustrates a modification of the heat transfer system shown in Fig. 2 and differs therefrom in that the vapor-lift action of fluid in the system is utilized to transfer surplus heat from the heat source to an element, such as a condenser, in one portion of the system. Only a fragmentary view of the generator 12 of the refrigeration apparatus is shown in Fig. 3 with parts similar to those shown in Fig. 2 referred to by the same reference numerals. In this modification the heat transfer system includes a member 86 in the form of a helical conduit which is disposed about and in heat exchange relation with a primary heat source, such as the exhaust pipe 11 associated with an internal combustion engine (not shown).

The upper end of the member 86 is connected by a conduit 87 to the lower end of a coil 88 arranged within a flue 8 which may be provided with a body 90 of suitable insulating material. The coil 88 may be heated by a burner 91 which serves as an additional or secondary heat source. The upper end of coil 88 is connected to a conduit 92 which in turn is connected to a conduit 93 extending into the upper part of the member 14b which is arranged within the lower part of the annular sleeve 13 of the generator 12. From the lower part of the member 14b depends a

conduit 94 which is connected to the lower end of the member 86. A looped or U-shaped conduit 95 is connected to the conduit 87 below the coil 88 and to the conduit 94 adjacent the upper end thereof. The conduit 95 serves the same function as the conduit 64 in Fig. 2 to by-pass liquid around the lower portion of the system when only the secondary heat source 91 is employed.

From the upper end of the coil 88 the conduit 92 extends into the upper part of a closed vessel 96 which is provided with a plurality of cooling fins 97. A conduit 98 which is connected to the lower part of the vessel 96 is provided with a plurality of cooling fins 99 and extends downward and is connected to the conduit 94 below the point that conduit 95 is connected thereto.

The heat transfer system shown in Fig. 3 is filled with a liquid, which does not readily evaporate, to the level indicated at B in conduit 92, so that the member 14b is filled with liquid. In the present instance the liquid employed is such that a temperature of about 200° C. is maintained in the member 14b. It is to be understood, however, that in other cases different liquids may be used to transfer the desired amount of heat to the place of heating. If heat is to be transferred to a hot water heater, for example, a suitable liquid is used to maintain a temperature of about 95° C. at the place of heating. The temperature maintained in the member 14b may also be regulated to a certain extent by arranging the member 86 of the system in heat exchange relation with warmer or cooler parts of the primary heat source. The operation of this system is similar to that described above in connection with the modification shown in Fig. 2 wherein the natural circulation of liquid in the system is effective to transfer heat from the exhaust gases or additional heat source 91 to the refrigeration apparatus.

When the high temperature exhaust gases first pass through the pipe 11 the liquid in member 86 is heated and circulation of liquid takes place in the portion of the system including conduit 87, coil 88, lower part of conduit 92, conduit 93, member 14b, and conduit 94 back to the member 86. During this period no circulation of liquid takes place through conduit 92, vessel 96, and conduit 98. When an abnormal increase in temperature occurs at the heat source whereby an undesirable quantity of heat would be transferred to the refrigeration apparatus, however, the liquid in the system will boil and, due to vapor-lift action, vapor and liquid pass upward through the small diameter conduit 92 into the vessel or condenser 96. The vapor condenses in the vessel 96 due to the cooling thereof by the surrounding cooler air, and the condensate and liquid which is pumped into the vessel together flow through conduit 98 and lower part of conduit 94 to the member 86. In this manner liquid normally flowing through the member 14b is by-passed to a certain extent so that surplus heat produced at the heat source is not transferred to the place of heating whereby undesirable overheating of the refrigeration apparatus is avoided.

The foregoing also takes place when only the additional or secondary heat source is employed and an abnormal increase in temperature is produced by the burner 91. In such case liquid pumped to the vessel 96 together with the condensate flows through conduit 98 and returns to coil 88 partly through conduit 95 and partly

through member 86. The conduit 98 may be provided with the cooling fins 99 to effect sufficient cooling of the liquid so that the exhaust gases and burner 91 are not capable of overheating the liquid in the system. It is not necessary to by-pass liquid to such an extent during overheating that no heat is transferred to the member 14b. In many instances it is preferable to insure circulation of liquid in the system through member 14b during overheating, and this may be readily accomplished by appropriate inclinations and proper connections of the different parts of the heat transfer system.

The modification shown in Fig. 4 is similar to that illustrated in Fig. 3 and differs therefrom in that the main portion of the heat transfer system and portion of the system provided for automatically controlling the quantity of heat transferred from the heat source to the place of heating do not form a single hermetically closed circuit. The main portion of the system is similar to that described above in connection with Fig. 3 and includes the member 86, conduit 87, coil 88, conduit 93c, member 14c, and conduit 94.

The generator 12c is divided into two chambers by a partition 100, and the vapor-lift coil 32 of the refrigeration apparatus is located in the lower chamber 101. Two conduits 92c and 98c connected to the chamber 101 extend upward and into the upper and lower parts, respectively, of the closed vessel 96c which is provided with cooling fins 97c. The member 14c is arranged within the lower end of the annular sleeve 13 and is in heat exchange relation with both the upper chamber of the generator 12c and the lower chamber 101. The closed circuit including chamber 101, vessel 96c, and conduits 92c and 98c contains a suitable fluid having such physical properties that it will boil when member 14c tends to rise above a predetermined temperature due to an abnormal rise in temperature of the heat source. When the fluid in chamber 101 begins to boil due to overheating, vapor and liquid pass upward through conduit 92c into the vessel 96c in which the vapor is cooled and condenses. The condensate and cool liquid pass down through conduit 98c into the chamber 101. It will be understood that the fluid takes up surplus heat into chamber 101, and that the vapor and liquid in the vessel 96c gives up such heat to the surrounding cooler air whereby the heating of the refrigeration apparatus is approximately controlled.

In some instances it may be desirable to transfer surplus heat due to overheating in an evaporation-condensation circuit similar to that shown in Fig. 1. In such case the conduit 92c is made sufficiently large in diameter so that only vapor will pass upward into the vessel 96c and circulation of liquid will not take place. When a liquid having a relatively high boiling point is used, the vessel 96c may be opened to the atmosphere in the manner described above in connection with vessel 66 of Fig. 2, whereby the boiling point of liquid can be regulated very closely without any appreciable loss of liquid in the system due to evaporation.

By locating the vapor-lift coil 32 of the refrigeration apparatus in chamber 101 considerable protection is given to this part of the apparatus inasmuch as it is the lowest part of the apparatus subjected to the high temperature of the heat transfer system. It will now be understood that a simple and reliable system has been provided which controls the quantity of heat

transferred from a heat source to a place of heating and which does not require valves or other regulating apparatus. Since the pressures of closed fluid systems of the character described for transferring heat in many instances are relatively high, relatively expensive regulating apparatus would be required to control safely the transfer of heat to the place of heating. The necessity of such regulating apparatus is completely avoided in my heat transfer system in which no moving parts are required and the control of heat transfer is automatically effected.

Instead of using a separate secondary heat source in my heat transfer system, such as an electrical heating element or a gaseous or liquid fuel burner, the system may be so constructed and arranged that energy derived from the primary heat source, such as the exhaust gases of an internal combustion engine, may be stored, and such stored energy may be used as the additional or secondary source of heat. Such a modification is shown in Fig. 5 in which a part of the heat transfer system is shown in heat exchange relation with a generator-absorber of a hermetically sealed intermittent refrigeration apparatus. In this modification the absorption refrigeration apparatus of the uniform pressure type is similar that shown in Figs. 1 and 2 with like parts indicated by the same reference numerals. The heat transfer system includes an evaporator member 102 in the form of a jacket about the pipe 11, a conduit 103 having a portion thereof in the form of a helical coil 104, and a condenser member 105 arranged within the lower end of the annular sleeve 13 of the generator 12. The heat transfer system contains a suitable fluid which evaporates in the jacket 102 and condenses in the member 105, in the manner described above in connection with the embodiment shown in Fig. 1, for transferring heat of the exhaust gases to the generator of the refrigeration apparatus.

Since the exhaust gases are at a relatively high temperature and a relatively large quantity is discharged through the pipe 11, it may be desirable to store such heat in the form of energy and use the same during the periods the internal combustion engine is not being operated. This may be accomplished by arranging the coil 104 in heat exchange relation with a generator-absorber 106 of an intermittent absorption system. The generator-absorber 106 is preferably heat insulated as shown and may contain a solid absorbing agent 107, for example, calcium oxide suitably treated as known in the art, or any of the various known liquid or solid absorbents, particularly those including an element of the halogen group.

Within the generator-absorber 106 extends a vertical conduit 108 which is provided with a plurality of openings 109 and is connected at its upper end to a jacket 110 disposed about the conduit 111 forming part of the condenser 15. The jacket 110 may be provided with a plurality of cooling fins 112 and connected by means of conduit 113 to an evaporator 114 arranged within the storage compartment 18 of the refrigerator cabinet.

When the internal combustion engine is being operated, the circulation of fluid in the evaporation-condensation circuit maintains the coil 104 at a high temperature whereby considerable heat is given off to the generator-absorber 106.

This causes expulsion of refrigerant, which may be methylamine, from the absorbent. The refrigerant vapor passes upward through conduit 108 into jacket 110 where it condenses, and the condensate flows into conduit 113 and accumulates in the evaporator 114. When the internal combustion engine is no longer being operated exhaust gases no longer pass through the pipe 11 whereby the temperature of the generator-absorber 106 is reduced. When the temperature of the generator-absorber has dropped sufficiently it is capable of absorbing refrigerant which flows from the evaporator 114 through jacket 110 and conduit 108 into the generator-absorber 106. The refrigerant within the evaporator is thus vaporized and withdraws heat from the surroundings to produce refrigeration. The absorption of refrigerant in the generator-absorber 106 releases heat which serves as an additional heat source for the evaporation-condensation circuit whereby liquid in the coil 104 is evaporated and passes upward to the member 105. The vapor condenses in the member 105 thereby giving up heat to the generator 12 and flows downward into the coil 104 in which it is again evaporated.

Since the generator-absorber 106 is insulated so that an effective heat exchange is maintained between the generator-absorber and coil 104, it is not expected that the temperature of the evaporator 114 will fall below 0° C. Nevertheless a certain amount of refrigeration is produced by the evaporator 114 which can readily be utilized. Further, the relatively cold vaporized refrigerant flowing through the jacket 110 may be effectively employed to cool the vaporized ammonia passing upward from the generator 12 to a much lower temperature than the ammonia can be normally cooled by surrounding air passing over the surfaces of the air-cooled condenser 15. By cooling the ammonia to a temperature lower than that attained during the normal operation of the continuous absorption system, it is possible to maintain the system in operation with the generator at a lower temperature. Therefore, the additional cooling of vaporized ammonia effected in the conduit 111 by the vaporized refrigerant in the intermittent system is particularly advantageous because the member 105 is maintained at a lower temperature when the heating is effected by the absorption of heat of the generator-absorber 106 than the temperature normally maintained when the primary source of heat is available. The reduction in pressure in the condenser 15, which is effected by the increased cooling of the vaporized ammonia, also tends to cause ammonia vapor in conduit 37 and the upper part of pressure vessel 36 to flow into and condense in the condenser 15 whereby an additional quantity of refrigerant flows into the cooling element 17.

By thus employing substances which combine with an exothermic reaction and in which the reaction is reversible, heat derived from the primary heat source may be stored in the form of energy which may be utilized as an additional source of heat when the primary heat source is not available. In any particular instance, it is only necessary to select such substances which will cause the liberation of one from the other at a temperature which is less than the temperature of the primary heat source. It is also desirable that the substances have such physical properties that the exothermic reaction, particularly when one substance has been expelled

from the other substance by heat, is sufficiently rapid to insure the production of an adequate quantity of heat for use as the additional heat source during the periods when the primary heat source is not available.

Instead of providing the cooling jacket 110 above the condenser 15 the cooling effected by the vaporized refrigerant in the intermittent system may be utilized to cool the entire condenser 15 or to effect additional cooling of the absorber 25. In many instances it may be particularly advantageous to provide a generator-absorber 106 of such size that the intermittent system will be of sufficient capacity to produce refrigeration in the storage compartment 18 for a relatively long period of time. This is possible during the night time, for example, since the losses are less during this period than at other times when the refrigerator cabinet is being used relatively frequently.

When the apparatus shown in Fig. 5 is used in connection with an internal combustion engine of a motor vehicle, the refrigeration produced by the provision of the intermittent system may be controlled whereby it can be utilized to produce cold at a particular set time. This may be accomplished by providing a valve 115 in conduit 108 which is normally open when the engine is being operated. When the engine is stopped the valve 115 may be closed to prevent immediate absorption of refrigerant in the generator-absorber 106 when the latter has cooled sufficiently to initiate an absorption period. Subsequently, when it is desired to reduce the temperature of the storage compartment 18 without operating the engine 10, the valve 115 may be open whereby the absorption of vaporized refrigerant by the absorbent generates heat, thus producing refrigeration in the storage compartment 18.

In view of the foregoing it will now be understood that I have provided an improved heat transfer system for transferring heat from a heat source to a place of heating. Although I have shown several embodiments of my improved heat transfer system in connection with an internal combustion engine and refrigeration apparatus operated by heat, I do not wish to be limited to the particular arrangements set forth, and I intend in the following claims to cover all modifications which do not depart from the spirit and scope of my invention.

What is claimed is:

1. In a method of heating with a source of heat by the aid of a system including two portions adapted to contain the same or different fluids in which said fluid within one portion of said system is normally caused to circulate to transmit heat from said source to a place of heating, that improvement which consists in causing said fluid or a different fluid to circulate within said other portion of said system upon increase in temperature of said source of heat, such circulation of fluid in said other portion of said system being effective to transmit additional heat produced at said source due to said increase in temperature to a medium in thermal relation with said other portion of said system.

2. In a method of heating with a source of heat by the aid of a system including two portions adapted to contain the same or different fluids in which said fluid within one portion of said system is normally caused to circulate to transmit heat from said source to a place of

heating, that improvement which consists in utilizing the increase in volume of said fluid or a different fluid to cause such fluid to circulate in said other portion of said system upon increase in temperature of said source of heat, such circulation of fluid in said other portion of said system being effective to transmit additional heat produced at said source due to said increase in temperature to a medium in thermal relation with said other portion of said system.

3. A heat transfer system including a first member associated with a primary source of heat, a second member associated with apparatus adapted to be heated and disposed above said first member, means including conduits connecting said members to provide a closed circuit so constructed and arranged that a part thereof is adapted to be associated with a secondary source of heat, said first and second members and connecting means being substantially filled with a liquid adapted to circulate in said circuit due to heating thereof to transfer heat from said primary or secondary source of heat to the place of heating, said connecting means including a portion providing an upward path of flow of liquid from said first member to said second member and another portion providing a separate downward path of flow of liquid from said second member to said first member, and conduit means connected to the two portions of said connecting means and always in unobstructed fluid communication with the latter, said conduit means being in parallel with said first member and connected in said system so that substantially no circulation of fluid takes place in said first member when the circulation of fluid in said circuit is due to heating of said part by the secondary source of heat.

4. A system for transferring heat from a source of heat to refrigeration apparatus operated by heat, comprising the combination of a first member associated with the source of heat, a second member associated with the refrigeration apparatus, conduit means connecting said members, said members and conduit means forming a circuit containing a fluid adapted to circulate therein due to heating thereof in said first member to transfer heat from the source of heat to the refrigeration apparatus, intermittent refrigeration apparatus including a generator-absorber, an evaporator, and a conduit connecting said evaporator and said generator-absorber, said generator-absorber being in heat exchange relation with a part of said circuit in which fluid is circulating when heat is being transferred from the source of heat to the refrigeration apparatus.

5. In a system for transferring heat from a primary source of heat to refrigeration apparatus including a generator, a condenser, an evaporator, and connecting conduits forming a first circuit for circulation of refrigerant, a second circuit containing a fluid and having a part associated with the source of heat and another part associated with the generator, a refrigeration system including a generator-absorber, an evaporator, and means connecting said generator-absorber and said last-mentioned evaporator, said generator-absorber being arranged in heat exchange relation with a part of said second circuit and said means connecting said generator-absorber and said last-mentioned evaporator having a portion arranged in heat exchange relation with a part of said first circuit.

6. In a system for transferring heat from a primary source of heat to a place of heating, a circuit containing a fluid and having a part associated with the source of heat and another part associated with the place of heating, a refrigeration system including a generator-absorber, an evaporator, and means connecting said generator-absorber and said evaporator, said generator-absorber being arranged in heat exchange relation with a part of said circuit in which fluid is circulating when heat is being transferred from the source of heat to the place of heating, and means for insulating said generator-absorber whereby the absorption heat produced therein is effectively transferred to said circuit.

7. A heat transfer system comprising a first member associated with a source of heat, a second member associated with the place of heating, conduit means connecting said members, said members and said conduit means forming a first circuit adapted to contain a liquid which circulates therein to transfer heat from the source of heat to the place of heating, and means including a conduit connected to said first circuit and extending above the normal liquid level in said first circuit to provide a second circuit for transferring heat from said first circuit to a medium in thermal relation with a part of said second circuit.

8. A heat transfer system including a first member associated with a source of heat, a second member associated with the place of heating, conduit means connecting said members, said members and said conduit means forming a first circuit adapted to contain a liquid which circulates therein to transfer heat from the source of heat to the place of heating, means including a conduit member connected to said first circuit to provide a second circuit in parallel with a part of said first circuit, said second circuit having a portion thereof above the normal liquid level in said first circuit.

9. In a method of heating with a source of heat by the aid of a system including a first portion having all parts thereof always in unobstructed fluid communication with each other and a second portion and in which fluid within said first portion of said system is normally caused to circulate to transmit heat from said source to a place of heating, that improvement which consists in utilizing a change of phase of fluid to cause circulation thereof within said second portion of said system upon increase in temperature of said source of heat, such circulation of fluid in said second portion of said system being effective to transmit additional heat produced at said source due to said increase in temperature to a medium in thermal relation with said second portion of said system.

10. In a method of heating with a primary source of heat with the aid of a system having all parts thereof always in unobstructed fluid communication with each other and containing a fluid in which such fluid is caused to circulate in said system due to heating by said primary source to transmit heat from the latter to a place of heating, that improvement which consists in addition utilizing a secondary source of heat, at a different part of said system than said primary source and in which fluid is circulating when heat is being transmitted from said primary source to the place of heating, to cause said fluid to circulate primarily in only a portion of said

system to transmit heat only by said fluid from said secondary source to the place of heating.

11. In a method of heating with a primary source of heat with the aid of a system having an upper portion and a lower portion and all parts thereof always in unobstructed fluid communication with each other and containing a fluid in which such fluid is caused to circulate in said system to transmit heat from said primary source to a place of heating, that improvement which consists in addition utilizing a secondary source of heat, at a different part of said system than said primary source and in which fluid is circulating when heat is being transmitted from said primary source to the place of heating, to cause said fluid to circulate primarily in the upper portion of said system without appreciably disturbing the fluid in the lower portion of said system to transmit heat by said fluid from said secondary source to the place of heating.

12. In a method of heating with a primary source of heat with the aid of a system having all parts thereof always in unobstructed fluid communication with each other and containing a fluid in which such fluid is caused to circulate in said system due to heating by said primary source to transmit heat from the latter to a place of heating, that improvement which consists in addition utilizing a secondary source of heat, at a different part of said system than said primary source and in which fluid is circulating when heat is being transmitted from said primary source to the place of heating, to cause said fluid to circulate in said system to transmit heat by said fluid from said secondary source to the place of heating, and regulating the secondary source of heat in accordance with a temperature condition affected by the primary source of heat.

13. In a method of transferring heat with the aid of a system including a first portion having all parts thereof always in unobstructed fluid communication with each other and a second portion and in which fluid within said first portion is caused to circulate to transfer heat from a first place of heating to a second place where heat is rejected, that improvement which consists in causing fluid to circulate within said second portion of said system with changes in temperature, such circulation of fluid in said second portion of said system being effective to transmit heat from said first place to a medium in thermal transfer relation with said second portion of said system.

14. In a method of transferring heat with the aid of a system including a first portion having all parts thereof always in unobstructed fluid communication with each other and a second portion and in which fluid within said first portion of the system is caused to circulate to transfer heat from a first place of heating to a second place where heat is rejected, that improvement which consists in utilizing change of phase of fluid to cause circulation thereof within said second portion of said system, such circulation of fluid in said second portion of said system, being effective to transfer heat from said first place to a medium in thermal transfer relation with said second portion of said system.

15. In a method of transferring heat with the aid of a system including two portions adapted to contain the same or different fluids in which fluid within one portion is caused to circulate to transfer heat from a first place of heating to a

second place where heat is rejected, that improvement which consists in causing the same or different fluid to circulate within said other portion of said system with changes in temperature, such circulation of fluid in said other portion being effected by vapor liquid lift action and effective to transmit heat from said first place to an object in thermal transfer relation with said other portion of said system.

16. In a method of transferring heat with the aid of a system including a first portion having all parts thereof always in unobstructed fluid communication with each other and a second portion and in which fluid in said first portion is caused to circulate to transfer heat from a place of heating to a second place where heat is rejected, that improvement which consists in causing fluid to circulate in said second portion of said system with changes in temperature, such circulation of fluid in said second portion being effected by vaporization of fluid in a region in thermal exchange relation with fluid circulating in said first portion of said system and condensation of such vaporized fluid in another region in said second portion of said system.

17. In apparatus comprising a continuous refrigeration system operated by heat and including a heat receiving part and an intermittent refrigeration system operating alternately with high pressure vapor expulsion periods and low pressure absorption periods and including a generator-absorber, a device constructed and arranged to cause heating of said heat receiving part by heat of absorption liberated by said generator-absorber during low pressure absorption periods of said intermittent refrigeration system, and control means for said intermittent refrigeration system to prevent a low pressure absorption period at the conclusion of a high pressure vapor expulsion period and operable to instigate a low pressure absorption period.

18. A method of transferring heat with the aid of a system including one portion having all parts thereof always in unobstructed fluid communication with each other and another portion and in which fluid circulates in said one portion to transfer heat from a source of heat to an objective of heating, flowing fluid in said other portion responsive to change in temperature, the fluid in said other portion being external to the path of flow of fluid in said one portion and adapted to be heated by the fluid in said one portion to control the transfer of heat from said source of heat to the objective of heating.

19. A refrigeration system operated by heat and including a cooling element and a heat receiving part, a first member adapted to be heated by a source of heat and a second member arranged to heat said heat receiving part, conduit means forming a first circuit in which heat transfer fluid is adapted to flow from said first member to said second member, a second circuit in which heat transfer agent is adapted to flow external to the fluid in said first circuit and having a part arranged to be heated as a result of circulation of heat transfer fluid in said first circuit, and said second circuit being constructed and arranged to modify a temperature condition affected by said cooling element.

20. A refrigeration system as set forth in claim 19 and including means to control circulation of heat transfer agent in said second circuit.

21. Apparatus operated by heat and including a heat receiving part, a first member adapted to be associated with a source of heat and a second

member in thermal transfer relation with said heat receiving part, conduit means connecting said members to form a circuit for circulation of a heat transfer agent to transfer heat from said source of heat to said heat receiving part, structure associated with such circuit and external to the path of flow of heat transfer agent in said circuit to regulate the transfer of heat by said heat transfer agent to said heat receiving part, and means responsive to a temperature condition affected by said source of heat for operating said last-mentioned structure.

22. Apparatus operated by heat and comprising a plurality of parts including a heat receiving part, a first member arranged to be heated by a source of heat, a second member in thermal transfer relation with said heat receiving part, conduit means connecting said members to form a circuit for circulation of a heat transfer agent which takes up heat at said first member from said source of heat and gives up heat at said second member to said heat receiving part, structure constructed and arranged to control circulation of heat transfer agent in said circuit to regulate the quantity of heat transferred by said heat transfer agent to said second member, and means responsive to a temperature condition affected by one of said apparatus parts for operating said last-mentioned structure.

23. In a method of heating with a primary source of heat by the aid of a system containing a fluid in which such fluid is caused to circulate within said system to transmit heat from said primary source to a place of heating, that improvement which consists in absorbing heat from a part of said system in which fluid is circulating during the periods when heat is being transmitted from said primary source to the place of heating, and utilizing the heat so absorbed as a secondary source of heat to cause said fluid to circulate and transmit heat from such secondary source to the place of heating.

24. In a method of heating with a primary source of heat by the aid of a system containing a fluid in which such fluid is caused to circulate within said system to transmit heat from said primary source to a place of heating, that improvement which consists in utilizing substances which combine with an exothermic reaction and in which such reaction is reversible to absorb heat from a part of said system in which fluid circulating during the periods when heat is being transmitted from said primary source to the place of heating, and utilizing the heat liberated during the exothermic reaction of said substances as a secondary source of heat to cause said fluid to circulate and transmit heat from such secondary source to the place of heating.

25. In a system for transferring heat from a source of heat to a heat absorbing element, the combination of a first circuit having all parts thereof always in unobstructed fluid communication with each other, with one part thereof associated with the source of heat and another part thereof associated with said element, said first circuit containing fluid adapted to circulate therein to transfer heat from the source of heat to said element, a second circuit adapted to contain a fluid and having a part in heat exchange relation with a portion of said first circuit, the fluid in said second circuit being adapted to circulate therein to transfer heat from fluid in said first circuit to a medium in thermal relation with a part of said second circuit.

26. In a refrigerator having a thermally in-

sulated space and absorption refrigeration apparatus including a cooling element arranged to effect cooling of said space, and a generator, heating means providing a region of high temperature, a heat transfer system comprising a first member positioned in said region of high temperature, a second member in thermal relation with said generator, and conduit means connecting said members, said members and conduit means forming a closed circuit containing a heat transfer agent adapted to circulate therein, means including a thermostatically operated valve for controlling flow of heat transfer agent in said circuit responsive to a temperature condition affected by said cooling element.

27. A refrigeration system operated by heat and including a cooling element and a generator, heating means providing a region of high temperature, a heat transfer circuit containing a heat transfer agent and including a heat receiving portion arranged to be heated by said region of high temperature and a heat rejecting portion in thermal relation with said generator, and structure responsive to a temperature condition affected by said cooling element and associated with said heat transfer system for controlling transfer of heat by said heat transfer agent to said generator.

28. In the art of refrigeration with the aid of an absorption refrigerating system including a part for absorbing heat at a high temperature, a part for absorbing heat at a low temperature, a part for giving off heat at an intermediate temperature, and means for circulating fluid between said parts, that improvement which includes supplying heat to the part for absorbing heat at a high temperature, and transferring heat normally utilized by the part for absorbing heat at a high temperature to a part for giving off heat at an intermediate temperature independently of the transfer of heat by the fluid in said system.

29. A refrigerating apparatus including a part adapted to be heated at a high temperature, a part adapted to absorb heat at a low temperature, a part adapted to give off heat at an intermediate temperature, fluid conveying conduits for connecting said parts together, means for heating the first mentioned part, and means for transmitting a variable amount of heat normally utilized by the first mentioned part to the third mentioned part independently of the heat transferred by fluid flowing in said conduits.

30. A refrigerating apparatus including a boiler, a condenser, and an absorber connected together to form a closed circulatory system for fluids, means for heating said boiler, and means for transmitting a variable amount of heat normally utilized by said boiler to said condenser independently of the heat transferred by fluid flowing within said system.

31. A refrigerating apparatus including a boiler, an air cooled condenser provided with heat dissipating flanges, an evaporator, and an absorber connected together to form a closed circulatory system for fluids, means for heating said boiler, and means for transferring a variable amount of heat normally utilized by said boiler to said flanges independently of heat conveyed by fluid flowing in said system.

32. A refrigerating apparatus including a boiler, an air cooled condenser, an evaporator, and an absorber connected together to form a closed circulatory system for fluids, means for heating said boiler, and means for transferring a variable

amount of heat normally utilized by said boiler to the air supplied to said condenser.

33. A refrigerating apparatus including a high temperature boiler and thermo-syphon pump, a low temperature evaporator and an intermediate temperature condenser and absorber connected together to form a closed circulatory system for

fluids, means for heating said boiler and thermo-syphon pump, and means for conveying a variable amount of heat normally utilized by said thermo-syphon pump to a lower temperature part of said system independently of heat conveyed by fluid flowing in said system.

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