June 15, 1937. H. H. MARSHALL 2,083,611

COOLING SYSTEM

Filed Dec. 5, 1931 2 Sheets-Sheet 1

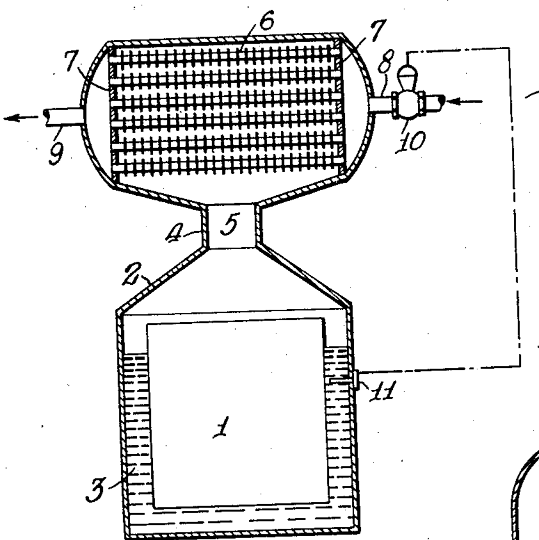

Fig. 1.

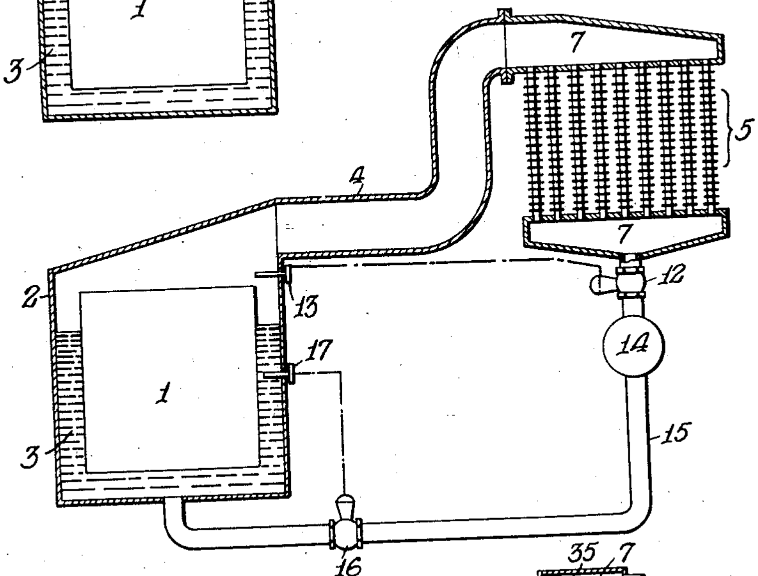

Fig. 2.

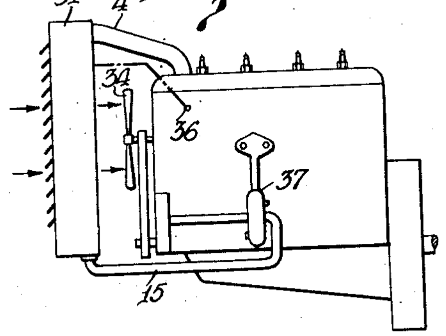

Fig. 6.

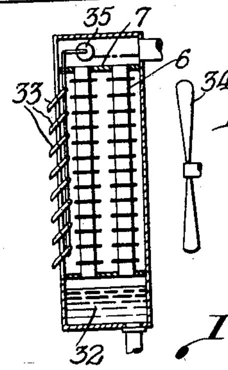

Fig. 7.

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June 15, 1937. H. H. MARSHALL 2,083,611

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Filed Dec. 5, 1931 2 Sheets-Sheet 2

Fig. 3.

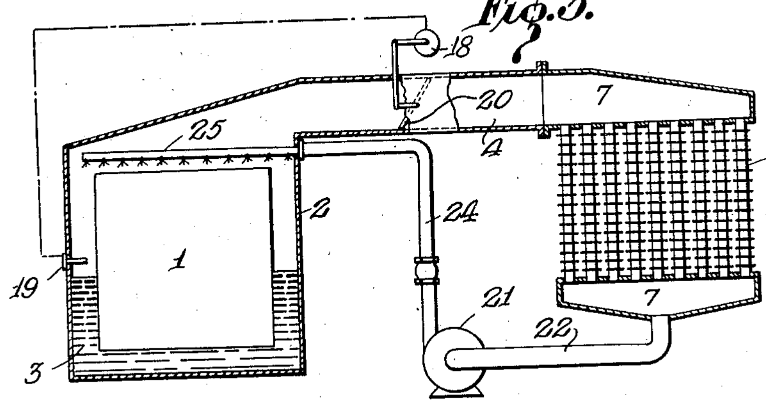


Fig. 4.

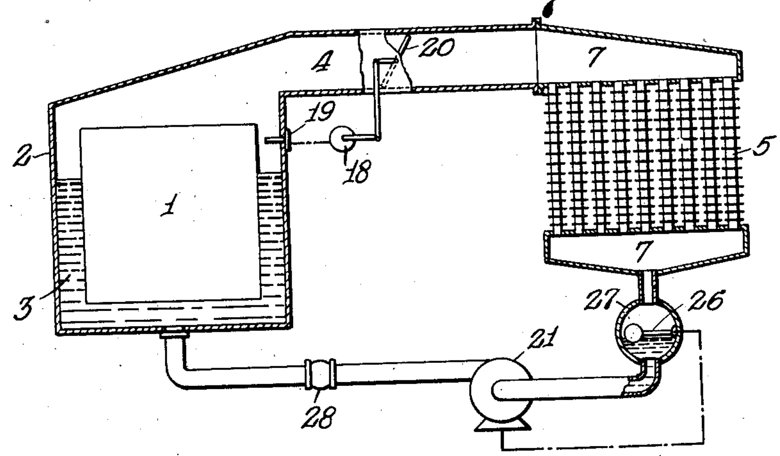
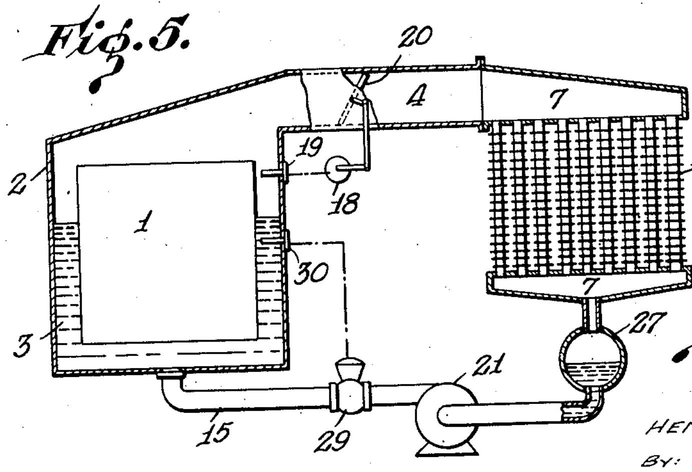


Fig. 5.



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UNITED STATES PATENT OFFICE

2,083,611

COOLING SYSTEM

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Application December 5, 1931, Serial No. 579,159

5 Claims. (Cl. 62—125)

This invention relates to an improved method and apparatus for the removal of heat at one temperature and the dissipation of the removed heat at some lower temperature.

The general object of the invention is to provide for the absorption of heat at a desired temperature, the absorbing medium being adapted to carry the heat to a point at which it is then dissipated to the atmosphere, or otherwise, at a lower temperature.

Another object of the invention is to provide means for controlling, within desired limits, the higher temperature at which this heat is absorbed, regardless of variations in the lower temperature at which the heat is subsequently dissipated.

In carrying out these objects, applicant employs a suitable medium, such as dichloromethane or dichloroethylene, or other refrigerants having related characteristics. This refrigerant is circulated about an apparatus to be cooled, and since its inherent characteristics enable it to be converted from liquid to vapor state, at comparatively slight pressures, exceedingly rapid and efficient heat exchange will take place in carrying on cooling operations, even at comparatively low temperatures. In the heat exchange step, the refrigerant, in absorbing heat, will be converted into a vapor. In the usual refrigeration cycle, this vapor would then be compressed, and after the compression operation, would be subjected to condenser action in which the vapor would be reconverted into liquid form. Applicant, however, has conceived that such compression is unnecessary in carrying on controlled cooling operations, where the temperature of the apparatus or medium to be cooled need not be lower than the temperature of the atmosphere or any desired medium adapted to be employed in reconverting a refrigerant from vaporous to liquid form. In practical application, therefore, a refrigerant such as dichloromethane could be circulated about a cylinder, of a gas engine, for example, remove heat therefrom, and in consequence, be converted, by evaporation, to a vapor. The vapor would then proceed to a condenser, cooled by water, or by air, the cooling step reconverting the refrigerant to liquid form. The liquid may then be returned to the cylinder and the operation repeated.

A feature of the invention resides in the provision of a condenser employed for converting refrigerant from vaporous to liquid state and means for governing the condenser action so that the rate of conversion of refrigerant to liquid state may be accomplished at a predetermined rate.

Another feature resides in the control of the temperature of an object to be cooled by means of a condenser adapted to convert refrigerant used in the cooling operation from vaporous to liquid form, the condenser being adapted to regulate the pressure at which said refrigerant is converted from liquid to vaporous form.

Still another feature resides in the provision of means in combination with a condenser whereby the rate of evaporation of a refrigerant may be controlled and the condensation of said refrigerant also controlled.

Another feature resides in using a refrigerant as a heat absorption medium in a closed cooling circuit, the circuit adapted to be sealed, and the cooling operation adapted to be efficiently carried on even though the amount of refrigerant remains constant under all operating conditions.

Other features making for efficiency and economy in operation and accomplishing desired methods of control by various means, including regulation of condenser cooling, adjustment of condenser surface, variation of evaporation and condenser pressures, and further advantages in structure and design in apparatus suitable for carrying out the invention, will be more apparent from the following description of the invention, to be read in connection with the accompanying drawings, showing illustrative forms of application, in which:

Fig. 1 is a diagrammatic view of a simple application of my invention,

Fig. 2 shows another form of my cooling arrangement illustrating a different method of control,

Figs. 3, 4, and 5 illustrate modified forms of applying the invention in the accomplishment of controlled cooling operations,

Fig. 6 shows the cooling system applied to an internal combustion engine, and

Fig. 7 is a section of part of the cooling system of Fig. 6.

Considering the drawings, more particularly Fig. 1, numeral 1 designates an area containing a source of heat. In practice, it may be a device, either electrical of mechanical, or a container in which a chemical process takes place, giving off heat at a constant or varying rate. Area 1 is surrounded by a jacket 2, containing a heat transfer medium 3, shown in liquid form. The jacket is connected by passage 4 to condenser 5. The condenser is formed, preferably, of a number of tubes

6, having finned surface thereon to facilitate heat transfer. The tubes are connected at their opposite ends to headers 7, suitably provided with supply and discharge lines, respectively designated 8 and 9. Valve 10 in the supply line operates responsive to control device 11. This device may operate responsive to changes in temperature or in pressure within jacket 2, and regulate the entrance of condenser cooling liquid to line 8. In practice, the arrangement of Fig. 1 will preferably operate with a refrigerant within the jacket, such as dichloromethane. Others, however, having similar or related characteristics, such as dichloroethylene, may also be used. Upon the generation of heat within area 1, some of the refrigerant liquid will evaporate, thus causing a transfer of heat from the chamber to the liquid. The vapor will then rise and enter condenser 5 through whose tubes 6 comparatively cold water will be circulating. The vapor will thereupon be condensed and drop back within the jacket. The control device 11 responds, as, for example, if it is a thermostatic device, to changes in temperature within the jacket. Thus, when more heat is generated in area 1, it will cause more water to pass through valve 10 and enter condenser 5, whereas, when less heat is given off, valve 10 will correspondingly be controlled to admit less water within the condenser. As a result, the condensing action is regulated responsive to variations in heat load produced within area 1. Area 1 will, therefore, be maintained substantially at constant temperature. The device 11, instead of being responsive to changes in temperature, may react similarly to changes in pressure. The result, however, will be the same.

Dichloromethane is preferred as a refrigerant because it is peculiarly adapted to achieve applicant's desired results. Its stability under almost all conditions within practical limits, its non-toxic character, the fact that it is non-inflammable, and that it will not corrode or coat surfaces, make it ideal for use as a cooling medium in an arrangement such as illustrated in simple form, by Fig. 1. Of particular importance, however, is the fact that dichloromethane is a liquid at atmospheric pressure at normal temperatures, under 105° F., and its escape from the system is of no moment, because it will resume the liquid form. Since it is non-inflammable, non-explosive and non-toxic, it will do no harm nor create any unsatisfactory conditions. Also, its operating characteristics require but comparatively slight pressure for its evaporation even at temperatures of several hundred degrees Farenheit, whereas, such refrigerants as ammonia or propane, under similar conditions, would require tremendous structures capable of withstanding pressures up to and exceeding one thousand pounds per square inch. Besides, such other refrigerants are both unstable, as well as dangerous.

Fig. 2 illustrates a more comprehensive method of applying the cooling arrangement shown in Fig. 1. Area 1 has a similar jacket 2 containing a heat transfer medium such as dichloromethane 3. The condenser 5 in this case is air cooled, instead of water cooled. Any suitable means, such as a fan, not shown, or natural circulation of air about the condenser may be relied upon to bring about the desired condenser cooling effect. Valve 12 at the discharge end of the condenser permits refrigerant in liquid form to leave the condenser, in controlled amounts. However, if valve 12 remains closed, liquid will be stored within the condenser and, in effect, reduce the effective condenser area. The operation of valve 12 is under control of device 13, which responds to changes either in temperature or pressure within the jacket. Reservoir 14 receives liquid passing through valve 12 which may then flow through line 15 and enter the jacket under control of valve 16. Valve 16 is under control of device 17 which may respond to changes in temperature (or pressure) within jacket 2. It is evident that instead of having two devices 13 and 17 for the control respectively of valves 12 and 16, only one device may be used, since both valves are similarly actuated under similar conditions. Two devices are shown because, in practice, it may be desired to actuate one valve responsive to temperature changes, whereas the other valve could more efficiently be operated responsive to pressure changes. The operation, as in Fig. 1, comprises the evaporation of refrigerant 3, due to the production of heat within the area 1. The vapor then passes to the condenser 5 and is reconverted into a liquid by an air cooling action. The valve 12, responsive to its control device 13, will allow the condensate to pass through in the event the heat load calls for further cooling. However, if the temperature conditions within area 1 do not require lowering of temperature, valve 12 will remain shut and allow the liquid to accumulate within the condenser tubes, thus cutting down the effective condenser area and correspondingly reducing the condensing action. It may be noted that as the liquid refrigerant accumulates in the condenser, the pressure on the evaporating liquid will be increased, with a consequent reduction in evaporation. As further cooling is required, due to increase in load, valve 12 will open and valve 16 will also open, thus permitting liquid to flow from the condenser back to the jacket. Reservoir 14 stores up excess liquid which is admitted by valve 16, so that the liquid level within the jacket may be maintained substantially at a desired point. Valves 12 and 16, therefore, serve respectively to maintain the temperature of area 1 substantially constant by regulating the condenser action and the level of liquid within the jacket. Not only is the control of level in the jacket important from the standpoint of maintaining substantially constant temperatures within the area but the maintenance of the jacket walls in wetted condition is highly desirable in effecting maximum heat transfer.

Figs. 3, 4 and 5 illustrate modified forms of applying the invention, showing various methods of control. In Fig. 3, damper 20 operates responsive to control 19, similarly situated as are controls 13 and 17 in Fig. 2. The damper motor 18 will, therefore, regulate the position of damper 20 within the passage connecting jacket 2 and condenser 5. This damper, in effect, regulates the pressure on the liquid in the jacket and thus controls the rate of evaporation. Pump 21 can draw liquid refrigerant through passage 22 from the condenser 5. The pump discharges the liquid through passage 24, leading to spray deck 25 situated at the upper or discharge end of the jacket. The pump operates continuously and a flood of spray, therefore, constantly serves the jacket and retains the walls wetted at all times. The rate of evaporation, as already noted, will be controlled by the pressure built up within the jacket by damper 20. The temperature of area 1 is retained substantially constant due to this control.

In Fig. 4, similar operation is provided, except that pump 21 is operated under control of means responsive to the position of float valve **26** within reservoir **27**. The reservoir serves to accumulate condensate, and when it reaches a certain level, the float valve will serve to actuate an electrical switch and close a related circuit for operating the pump. A switch of any suitable design may be used whose contacts may be closed when the float reaches one position, and broken when the float reaches another position. The use of this control assures the maintenance of a substantially constant level of liquid within the jacket. Damper **20**, as in Fig. 3, is controlled by motor **18**, in turn operative responsive to changes in conditions affecting device **19**, and hence controls the rate of evaporation by governing the pressure on the liquid in the jacket. Check valve **28** is arranged to prevent the liquid flowing back to the pump from the jacket, whenever the pump is inoperative.

Fig. 5 represents another variation in the method of control. Valve **29** is here under control of device **30** which responds, as in Figs. 3 and 4, either to changes in pressure or temperature within the jacket. When the temperature rises, as in the case of an increasing load, device **30** will cause valve **29** to open and the pump **21** will thereupon supply liquid from reservoir **27** to the jacket. The pump is of the centrifugal type and hence may operate continuously, supplying liquid as requirements demand whenever the regulating device operates valve **29**. This arrangement obviates the necessity for a controlled motor circuit, as, for example, shown in Fig. 4. The control of temperature within area **1** is, as in Figs. 3 and 4, carried on by damper **20** which regulates the pressure on the liquid within the jacket and hence the rate of evaporation.

In Figs. 6 and 7, applicant illustrates a practical embodiment of his invention, in connection with the cooling of an automobile or internal combustion engine. In effect, the internal combustion engine here illustrated takes the place of area **1** shown in the other figures. The engine may be of conventional design, and, per se, forms no part of the invention. The cooling system may include the usual jackets about the cylinders and various other elements such as connections, pump, reservoir, and radiator. The radiator **31** takes the place of the condenser **5** shown in the other figures. A suitable reservoir or receiving tank **32** is located in the bottom of the radiator. A series of louvres **33** are suitably positioned in front of the radiator, so that onrushing air responsive to the forward motion of the motor or vehicle in which the motor is located will pass through the tubes of the radiator in varying amount depending upon the position of the louvres. A fan **34** provided in the usual manner and operative from one of the shafts of the motor may be used to draw air through the radiator and in contact with the tubes thereof, so that the cooling operation may be carried on even though the engine remains stationary. The control motor **35**, analogous in construction to the damper motor **18** of Figs. 3, 4 and 5, operative responsive to control device **36**, shown on Fig. 6, regulates the position of louvres **33**. Thus, as the engine requires more cooling effect, control device **36** will cause the damper louvre control motor **35** to open louvres **33** wider, so that more air will pass over the tubes of the radiator, thereby producing greater cooling effect. Of course, whenever the engine speeds up, fan **34** and pump **37** are also speeded up. However, unless the heat were not dissipated fast enough, the louvres **33** would remain unaffected. However, if, as, for example, under a load, the engine did not speed up, but the amount of heat to be dissipated increased, the control **35** would be actuated and cause louvres **33** to function so that more air would pass the radiator tubes. Thus, by controlling the condenser action in the radiator, the temperature of the engine would be maintained substantially constant. It should be observed that not only is the method of control peculiarly adapted to maintain desired constant temperature conditions, but the use of refrigerants such as dichloromethane has many other salutary advantages. The refrigerant may be sealed in, so that in amount it always remains the same and yet its cooling effect can be varied, depending upon changes in rate of evaporation, controlled through regulation of the condenser action. The danger of freezing does not exist. Furthermore, but a small quantity of refrigerant is required, compared to the amount of water, for example, needed to accomplish similar results; but the more important factor is that the condensing surface required with this refrigerant is much smaller than that of the conventional radiator of equal capacity. Also, the use of refrigerant such as dichloromethane would not rust the interior of the jackets, nor would ever require replacement or inspection during the life of the engine.

While the invention is shown applied to an internal combustion engine, it is obvious that a cooling arrangement of similar design may be adapted in countless systems wherein the dissipation of heat and the maintenance of substantially constant temperatures is desired. The methods of control shown in the drawings are not to be construed as limiting, but merely as illustrative of the ways in which the invention may be applied.

It is intended that the foregoing description and the accompanying drawings be regarded as illustrative only and not in a limiting sense, applicant limiting himself only as indicated in the accompanying claims.

What I claim is:

1. A method of maintaining constant the temperature of an object containing a source of heat consisting in surrounding said object with a liquid adapted to evaporate, and controlling the rate of evaporation by continually passing a condensing fluid in heat exchange relation with the vapors resulting from the evaporation of said liquid and quantitatively regulating the flow of condensing fluid.

2. A method of maintaining constant the temperature of an object containing a source of heat consisting in surrounding said object with a liquid adapted to evaporate, whereby said liquid is vaporized, condensing the resultant vapors, at substantially the same pressure as the pressure with which these vapors were formed, by passing a cooling medium in heat exchange relation with the vapors at all times, returning the condensate for re-evaporation, and quantitatively controlling the amount of cooling medium passed in heat exchange relation with said vapors by the temperature of said liquid.

3. A method of regulating the temperature of an object to be cooled consisting in evaporating

a liquid in contact with the object, condensing the resultant vapors, at substantially the same pressure as the pressure at which these vapors were formed, by causing a change in the sensible heat only of a cooling medium by passing the same in heat exchange relation with the vapors, returning the condensed liquid so that it may again contact with said object, and regulating the flow of cooling medium by variations in the amount of heat to be dissipated.

4. A method of regulating the temperature of an object to be cooled consisting in wetting the surface of said object with a volatile fluid whereby the fluid is evaporated, condensing the resultant vapors, at substantially the same pressure as the pressure at which these vapors were formed, by continuously, and at all times, circulating a cooled medium in heat exchange relation with the vapors, and controlling the rate of condensation by regulating quantitatively the flow of cooling medium by the temperature of said fluid.

5. A method of cooling an object subjected to varying heat loads consisting in wetting the surface of said object with a volatile fluid whereby the fluid is evaporated, condensing the resultant vapors, at substantially the same pressure as the pressure at which the vapors were formed, by continuously causing a change in the sensible heat of a cooling medium by circulating the same in heat exchange relation with the vapors, and controlling the rate of condensation by regulating quantitatively the flow of cooling medium.

HENRY H. MARSHALL.