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PORTABLE COOLING DEVICE FOR FLUIDS AND FOOD

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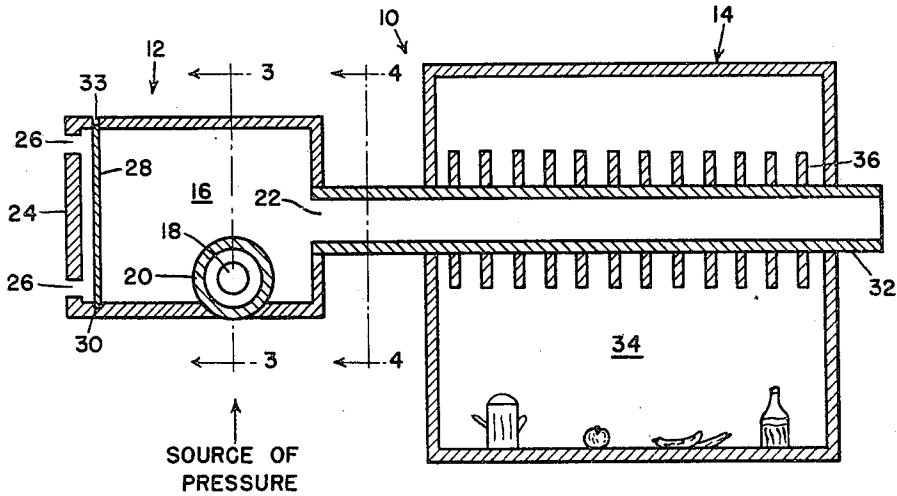


Fig. 1

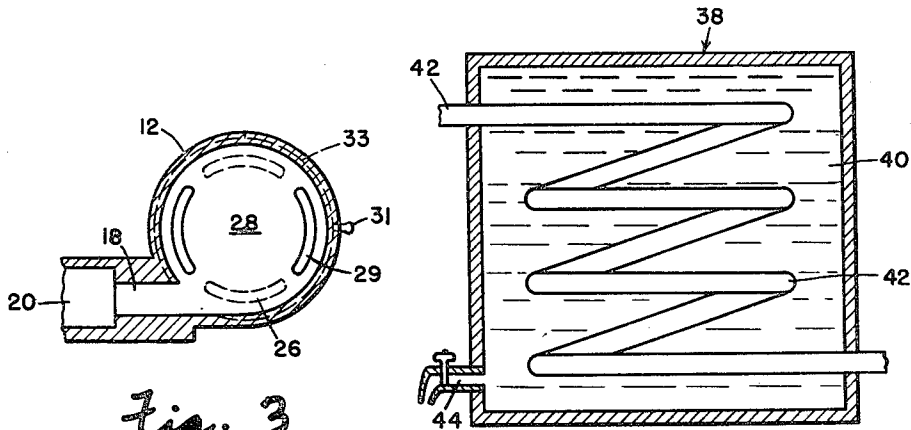


Fig. 2

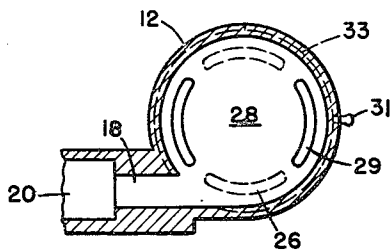


Fig. 3

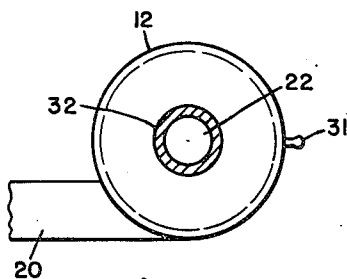


Fig. 4

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PORTABLE COOLING DEVICE FOR FLUIDS AND FOOD

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3 Claims. (Cl. 62—96)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The invention relates to a portable cooling device and method whereby simplified and inexpensive refrigeration is provided.

It has long been desired to provide an inexpensive means to cool foods and liquids, while being transported. Portable refrigerators have been used, but are cumbersome and relatively expensive. In addition, the conventional means of cooling is carried out by the use of ice. Valuable space is thus forfeited to provide room for the cooling medium which, when melted, requires disposal. The instant invention avoids the necessity for using ice, or other means of cooling, by applying the principle of the vortex or Ranque tube.

A primary object of the invention is to provide refrigeration for a portable container.

Another important object of the invention is to avoid the use of expensive material to obtain the cooled condition.

Yet another object of the invention is to avoid the use of any moving parts to provide refrigeration.

A more specific object of the invention is to apply cold air to a heat exchanger to cool said heat exchanger.

Another specific object of the invention is to provide a vortex tube with the cold medium outlet connected to a portable container to supply the refrigerant for cooling.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 is a vertical section of the invention,

Fig. 2 is another form of heat exchanger that may be used,

Fig. 3 is a section taken on line 3—3 of Fig. 1, and

Fig. 4 is a section taken on line 4—4 of Fig. 1.

The vortex tube used is of the counterflow type where the two streams of gas travel in opposite directions. The vortex tube consists of a cylindrical tube with an annular, peripheral outlet at one end for the heated gases and a coaxial central outlet at the other end for the cooled gases. This simple, central, circular hole as outlet for the cold gases provides an entirely satisfactory performance and a standard pipe or tubing may be used in the construction. A nozzle to admit the fluid medium under pressure is illustrated and it is essential that this nozzle introduce the gas tangentially to the inner cylinder wall to give satisfactory performance. Obviously, a plurality of nozzles may be used, in which case they would be distributed evenly around the tube in the same plane. The advantage of this, is to provide a more symmetrical vortex with somewhat improved performance. However, where cost is material, a single nozzle gives excellent results.

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In operation, the working fluid, generally air, enters the inlet nozzle and is discharged into the cylinder tangentially, creating a vortex. A portion of this fluid, depending upon design and control, discharges through the cold outlet, and the remainder through the hot side. Several theories have been advanced to explain the principle of operation. The most accepted one considers the temperature differences obtained as being due to a migration of kinetic energy due to viscous shear stresses within the rotating mass of gas produced by fluid under pressure entering the cylinder. The vortex resulting adheres to the law of constant angular momentum, where the velocity times the radius of any particle is a constant. Thus, the inner radius of the cylinder near the axial center is small, and the radius increases towards the inner periphery of the cylinder with the tangential velocity highest at the axis of the tube and the least at the periphery. This is an example of irrotational flow. Velocity distribution is changed by the tendency of any viscous flow to equalize its velocity distribution as the vortex expands axially and the irrotational flow changes to rotational flow. This changing velocity distribution causes transfer of kinetic energy towards the periphery of the cylinder, causing the temperature of the outer gas layers to be raised and the temperature of the inner gas layers to fall. But, since a temperature difference exists in the gas, a heat transfer result, where the heat energy flows from the hot outer layers to the cold inner layers. A rotational flow near the axis builds up and the pressure of the gas increases, as well as a pressure gradient towards the cold orifice. While this conversonal flow builds up, the innermost layers separate and proceed out of the cold orifice, this action continuing until the irrotational flow converts to a rotational one. The remaining heated gas travels out of the other end of the cylinder. The difference in temperature of the two streams is due to the fact that the overall kinetic energy flux outward is greater than the heat flux inward. Friction also supplies heat energy to the complete energy exchange of the gases.

Referring more specifically to the invention, the application of the vortex tube to provide refrigeration is illustrated in the figures and is designated as a whole at 10. Figures 1, 3 and 4 disclose in detail the vortex tube 12 and the heat exchange member 14.

Vortex tube 12 comprises a cylindrical pressure chamber 16 having a tangential inlet 18 for a fluid medium nozzle 20. A gas under pressure is supplied to the nozzle 20 and may be obtained in any desired manner. Thus, pressure from a hand air pump, or from an idling piston and cylinder operated off an automobile engine pulley, or from pressure vessels, may be utilized in the operation of the invention. A gas bulb, or pressure bled from one of the cylinders of an automobile engine from which the ignition plug has been removed, are other sources of fluid. These are merely exemplary and other mechanical, electrical or pneumatic means may be used.

Nozzle 20 is as close to orifice 22 as is practical. The hot air side of tube 12 is provided with a plate or wall 24 annularly slotted at 26 for escape of the heated fluid medium. A throttle valve disk 28, suitably apertured at 29, is rotatably retained in an annular groove 30 in the wall of chamber 16 to control the rate of escape of the heated gases. Control knob 31 extends through slot 33 in the wall of chamber 12 and is manipulated to control the amount of heated fluid escaping through outlets 26. While a valve plate is shown, it is obvious other valve structures could be substituted, such as gate valves, within the scope of the invention.

Axial orifice 22 receives one extremity of an elongated conduit pipe 32, the major length of conduit 32 extending through heat exchange chamber 34 of a size large enough

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to hold the articles desired to be cooled. Cooling fins 36, or other suitable transfer means are provided to quickly cool refrigerator chamber 34. Obviously, conduit 32 may terminate at the point of entry into chamber 34, thereby allowing the cold air to expand directly in the chamber. In this case an exit orifice is provided to permit the escape of the air after it has served its purpose.

Another form of heat exchange means 38 is shown in Fig. 2 and comprises a chamber 40 receiving a cooling coil 42 therethrough to convey the refrigerated gases from vortex chamber 16 in heat exchange relation with a liquid retained in chamber 40. Spigot 44 is provided near the base of heat exchanger 38 to permit the cooled liquid to be withdrawn. Insulation for heat exchangers 14 and 38 may be provided, if desired. Conduits 32 and 42 are preferably constructed of copper. However, this is not critical, as any conductive material may be used.

The operation of the cooling device is readily apparent. There are no moving parts and the device is of extreme mechanical simplicity. Vortex tube 12 produces a large temperature difference between the two gas streams, with cold temperatures obtained as low as -50° F.

A gaseous fluid under pressure, such as air, is introduced through nozzle 20 into chamber 16 of the vortex tube. Two streams of gases are obtained by the vortex created due to the tangential position of the nozzle, one at a higher and one at a lower temperature than the original air stream. The heated fluid passes out through peripheral slots 26 at one side of the tube and the cooled fluid passes through axial outlet 22 at the opposite side of the tube. Control of the fluid temperatures is provided by means of valve disk 28. The cold air is transferred through conduits 32 or 42 into cooling chambers 34 or 40, respectively, to provide the desired refrigeration.

The device is capable of many uses. A container with food, or liquids, now may be cooled directly or indirectly by transfer of cold air obtained from a vortex tube into the container, which is actually a portable refrigerator. The principle of the invention could be applied equally well to air conditioning automobiles or other mobile conveyances, such as trains, ships, airplanes, etc. The vortex tube 12 and the refrigerator chambers require no moving parts, and as a result, maintenance is not a factor. Readily available materials are used in the manufacture of the device and, preferably with air under pressure, as the fluid

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medium. Thus, the cost of production is extremely low.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A portable refrigerator unit comprising a cylindrical chamber, inlet means tangentially secured to said chamber to supply an incoming air stream whereby an outer heated portion and a coaxial cooled portion are obtained by rotational action of the incoming air stream in the cylindrical chamber, an annularly slotted outlet at one end of said chamber, said annularly slotted outlet being adjacent the periphery of said cylindrical chamber, a valve disk rotatably mounted in said chamber adjacent said slotted outlet to control the flow of the heated portion, an axial outlet at the other end of said chamber, a refrigerator chamber connected to said axial outlet and heat exchange means in said refrigerator chamber.

2. The combination of claim 1 wherein said slotted outlet comprises a pair of opposed arcuate slots and said valve disc contains complementary arcuate slots whereby the amount of heated and cold air is controlled in said cylindrical chamber.

3. The combination of claim 1, wherein said cylindrical chamber includes an annular groove retaining said disk therein, a slot in the wall of the chamber, and handle means extending through said slot and connected to the peripheral edge of the disk whereby the disk is rotated to progressively control the amount of heated air escaping from the vortex chamber.

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