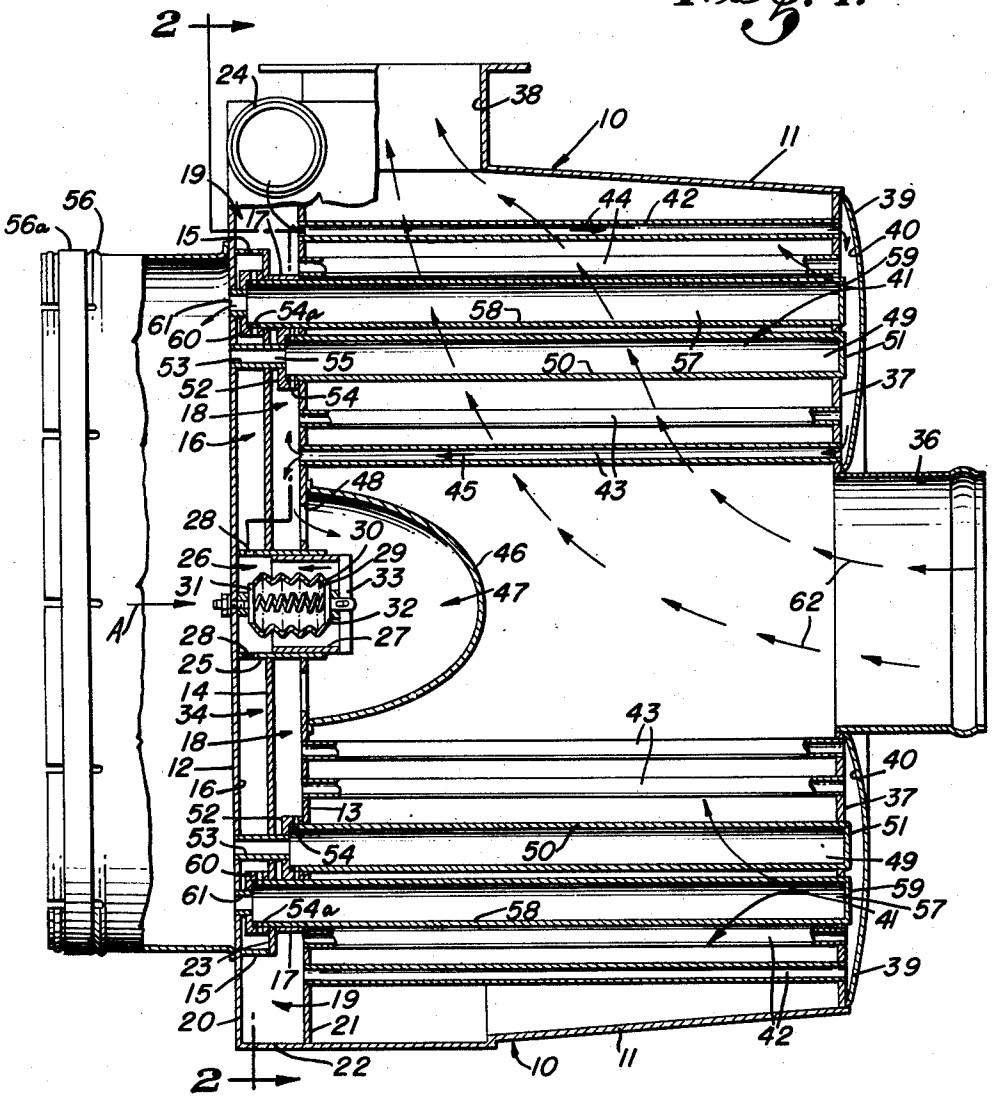
June 30, 1959 F. H. GREEN 2,892,316

AIR CONDITIONING DEVICE

Original Filed June 29, 1950 2 Sheets-Sheet 1

Fig. 1.



FREDERICK H. GREEN,
INVENTOR.

BY

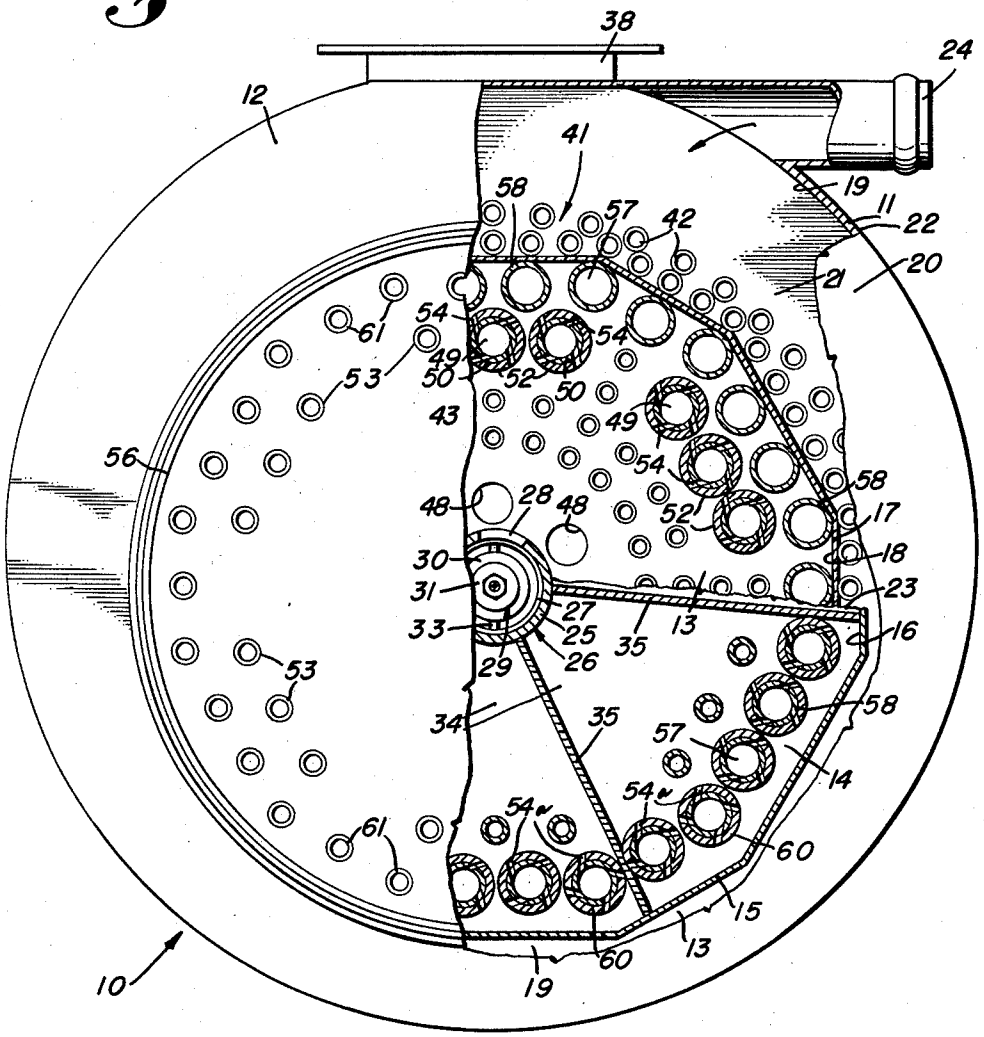
Attorney

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Fig. 2.



FREDERICK H. GREEN,
INVENTOR.

BY

Attorney

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2,892,316

AIR CONDITIONING DEVICE

Frederick H. Green, Palos Verdes Estates, Calif., assignor to The Garrett Corporation, Los Angeles, Calif., a corporation of California

Original application June 29, 1950, Serial No. 171,147, now Patent No. 2,839,898, dated June 24, 1958. Divided and this application January 25, 1957, Serial No. 636,323

8 Claims. (Cl. 62—5)

This application is a division of my copending application, Serial No. 171,147, filed June 29, 1950, issued as Patent No. 2,839,898, dated June 24, 1958 for Multiple Vortex Tube Generator Cooling Unit, and relates to a heat exchanger employing tubes having the general characteristics of the vortex tube disclosed in U.S. Patent No. 1,952,281, granted March 27, 1934, to Georges J. Ranque, but constituting an important improvement thereover. The Ranque patent disclosed a manner and means whereby a stream of compressed air may be divided into two streams, one of which is cooled and the other of which is heated. The Ranque tube has at its front end a tangential inlet opening for the compressed air and an axial opening for the stream of cooled air, and at the rear end of the tube an opening for the stream of heated air.

It is an object of the invention to provide in an air cooling device including a tube having at one end thereof an inlet opening to receive a stream of compressed air and adjacent the inlet opening an outlet for the air which has been cooled, the invention including means separate from or in addition to the compressed air which enters the tube through the inlet opening for removing heat from the air within the tube. In the invention disclosed herein it is not necessary to remove air from the tube except through the cooled air outlet opening and, therefore, wastage of compressed air by discharging it from the rear end of the tube may be avoided. Herein the term, air, is employed in its broad meaning of any gaseous medium or mixture.

It is an object of the invention to provide a compact device having walls defining a plenum chamber through which a plurality of heat conductive tubes are extended, each tube being closed at one end and having at its other end an inlet opening which communicates with the plenum chamber and an axial outlet opening which communicates with a space adapted to receive cooled air, there being a duct for the delivery of fluid under pressure to the plenum chamber so that it will be caused to flow into the tubes through the inlet openings thereof and within the tubes to the outlet openings thereof, and there being also means for establishing a path of flow for another fluid over the exteriors of the tubes to remove from the tubes heat which has been transferred to the tube walls from the fluid flowing therein.

It is a further object of the invention to provide a device of this character having simple and effective means for causing the fluid which enters the inlet openings of the tubes to flow toward the ends of the tubes opposite from the ends thereof which have therein the inlet and outlet openings, and wherein the fluid then reverses its flow and travels to and through the outlet openings.

Further objects and advantages of the invention will be brought out in the following part of the specification wherein I have described a preferred embodiment of the invention in detail for the purpose of making an extensive disclosure of the invention without intending, however, to limit the scope of the invention which is set forth in the appended claims.

Referring to the accompanying drawings which are for illustrative purposes only:

Fig. 1 is a longitudinal sectional view of a simple form of the cooling device;

Fig. 2 is an end view of the device shown in Fig. 1 taken from the position of the letter *a*, the view being sectioned as indicated by the line 2—2 of Fig. 1.

The cooler 10 has a shell or wall 11 of generally cylindric form but being slightly tapered from the front toward the rear end thereof. A front wall 12 is mounted at the leftward end of the wall 11. Spaced inwardly from the wall 12 there is a plate 13, the diameter of which is substantially the same as the diameter of the wall 11 at the plane of the plate 13. Between the wall 12 and the plate 13 there is an intermediate wall 14, the periphery of which is connected to the wall 12 by a strip wall 15. The wall 14, the strip wall 15 and the portion of the wall 12 lying within the limits of the strip wall 15, define a plenum chamber 16. A strip wall 17 extends from the wall 14 to the plate 13 and cooperates with the plate 13 and the wall 14 in forming a flat plenum chamber or air duct 18 adjacent a portion of the front face of the wall 13.

An air inlet chamber 19 of annular form is defined by the peripheral portions 20 and 21 of the wall 12 and the plate 13, the portion 22 of the wall 11 therebetween, the strip walls 15 and 17 and an annular portion 23 of the intermediate wall 14. The inlet chamber 19 is supplied with compressed air from a source of air under pressure, such as the bleed from the high pressure outlet of a jet engine compressor in an aircraft, through an inlet fitting 24 which may be arranged tangentially, as shown.

A cylindric wall 25 is disposed axially of the shell 10 and is carried by the central portions of the walls 12 and 14 and the plate 13. This cylindric wall 25 forms part of a valve mechanism 26 having a cylindric closure member 27 which is slidable within the cylindrical wall 25, and is moved relatively to ports 28 through the wall 25 by pressure responsive control means 29. The pressure responsive means is shown as having a spring-expanded aneroid bellows 30 with one end wall 31 thereof connected to the wall 12 and the other end wall 32 thereof connected to a crossbar 33 which is fixed on the rightward end of the closure member 27.

The chamber 16 is divided into a plurality of manifolds or plenum chambers 34 by radial walls 35. In the form of the invention disclosed herein there are six of the radial walls 35 dividing the chamber 16 into six manifolds 34 to which compressed air is fed selectively through the ports 28 under control of the closure member 27 which is moved by the pressure responsive control means 29.

The coolant air inlet 36 is supported in the center of a rear end plate 37 disposed at the rightward end of the wall 11. The coolant air outlet 38 is supported by the wall 11 near the leftward end of the shell 10. An annular plate 39 is secured to the rightward end of the shell 10 in a position surrounding the coolant air inlet 36 so as to provide externally of the plate 37 an air chamber or passage 40 which cooperates in the formation of a heat exchanger or preliminary cooler 41 within the shell 10. This heat exchanger 41 comprises a first bank of tubes 42 arranged annularly so as to connect the inlet chamber 19 with the peripheral portion of the chamber 40. A second bank of tubes 43 is arranged to connect the inner portion of the chamber 40 with the chamber 18. The ends of the tubes 42 and 43 are supported by the plates 13 and 37, as shown in Fig. 2. Hot compressed air, entering the chamber 19 through the inlet 24 follows a path through the tubes 42, the chamber 40 and the tubes 43 into the chamber 18, as indicated by ar-

rows 44 and 45. A dome or cap 46, secured to the face of the plate 13 provides a chamber 47 communicating with the inlet of the valve 26, and openings 48 are provided in the plate 13 connecting the chamber 18 with the chamber 47.

Continuously operating vortex tubes 49 are supported between the banks of tubes 42 and 43 by the plates 13 and 37 so as to extend through the plenum chamber 18. Each of these continuously operating vortex tubes 49 includes a hot tube portion 50 having a disc 51 closing its rear end and having a cap 52 on its front end, each cap 52 supporting a cooled air outlet tube 53 coaxially of the hot tube portion 50. The caps 52 of the vortex tubes 49 are arranged in the peripheral portions of the plenum chamber 18, and tangential openings 54 pass through the circumferential walls of the cap 52 and the adjacent portions of the tube parts 50, to provide inlet nozzles or ports communicating with the ends of the hot tube portions 50 adjacent the cooled air outlets 55 provided by the tubes 53. These tubes 53 extend leftwardly from the caps 52 through the walls 14 and 12 respectively and deliver cooled air into a cooled air outlet duct fitting 56 of cylindric form which is secured to the leftward face of the wall 12. The outlet fitting 56 is provided with a clamping band 56*a* for securing it to the end of a generator or other cylinder part.

Intermittently operating vortex tubes 57 are supported by the plates 13 and 37 outwardly of the vortex tubes 49 and extend through wall 14. These vortex tubes 57 have hot tube portions 58 with discs 59 closing their rear ends. The hot tube portions 58 extend through the plate 13 and the wall 14 into the manifolds or plenum chambers 34, and on the ends of the hot tube portions 58 projecting into the manifolds 34 caps 60 are fitted, which caps 60 support cooled air outlet tubes 61 which connect through openings in the end wall 12 with the interior of the cooled air outlet fitting 56. The caps 60, similar to the caps 52, have tangential openings 54*a* which communicate through the adjacent walls of the hot tube portions 58. In the operation of the cooling device near sea level, the pressure responsive means 29 will hold the valve closure 27 in a position closing all of the ports 28, and air will pass through the tubes 42 and 43, in heat exchange relation to coolant air which travels from the inlet 36 to the outlet 38 as indicated by arrows 62 in Fig. 2. This partly cooled air is delivered from the tubes 43 into the chamber 18, from which there will be a continual flow of air through the nozzles 54 into the vortex tubes 49. The coolant air from the duct 36 moving as indicated by the arrows 62, will likewise cool the hot tube portions 50 of the vortex tubes 49 and from the outlet tubes 53 of the vortex tubes 49 there will be an issue of cold air which will be delivered by the outlet fitting 56 to the selected receiving means.

Although I have shown cooling substantially all of the hot tube portions 50, it is within the invention to cool only selected parts of the hot tube portions. The inlet openings 54 and 54*a* and the outlets 55 and 61 of the tubes 49 and 57 are disposed adjacent like ends of the tubes 49 and 57. Means are provided for causing the air which enters through the inlet openings 54 and 54*a* to travel rightwardly within the tubes, this rightward flow of fluid being followed by a reversal of flow so that the fluid travels leftwardly along the tube axes to and through the outlets 55 and 61. The tangential arrangement of the inlet openings 54 and 54*a*, as shown in Fig. 2, causes the air to swirl at high velocity within the tubes so that centrifugal force acting therein causes the air to follow a path close to the tube inner surface, and the entering stream of air displaces that which has already entered thereby causing the swirling air to move rightwardly along the interiors of the tubes 49 and 57.

I claim:

1. A heat exchanger, comprising: walls defining a plenum chamber; a first duct communicating with said chamber; a plurality of heat exchange tubes, each closed at one end and open at the other, said tubes extending through said chamber with said closed and open ends disposed exteriorly thereof; a second duct communicating with said open ends of said tubes; passageways through the walls of said tubes providing communication between said plenum chamber and the interiors of said tubes, and thereby establishing paths of flow for a fluid between said first and second ducts, said paths including the interiors of said tubes; and means establishing a path of flow for another fluid over the exteriors of said tubes in heat exchange relationship with the fluid flowing through the interiors thereof.

2. A heat exchanger comprising: walls defining a plenum chamber; a first duct communicating with said chamber; a plurality of heat exchange tubes, each closed at one end and open at the other, said tubes extending through said chamber with said closed and open ends disposed exteriorly thereof; a second duct communicating with said open ends of said tubes; passageways through the walls of said tubes providing communication between said plenum chamber and the interiors of said tubes, and thereby establishing paths of flow for a fluid between said first and second ducts, said paths including the interiors of said tubes; means for directing the flow of said fluid along the interior walls of said tubes from said open ends toward said closed ends, said tubes being provided with centrally disposed passageways for discharge of said fluid; and means establishing a path of flow for another fluid over the exteriors of said tubes in heat exchange relationship with the fluid flowing through the interiors thereof.

3. A heat exchanger comprising: walls defining a plenum chamber; a first duct communicating with said chamber; a plurality of heat exchange tubes, each closed at one end and open at the other, said tubes extending through said chamber with said closed and open ends disposed exteriorly thereof; a second duct communicating with said open ends of said tubes; passageways through the walls of said tubes providing communication between said plenum chamber and the interiors of said tubes, and thereby establishing paths of flow for a fluid between said first and second ducts, said paths including the interiors of said tubes, there being means in said tubes adjacent the open ends thereof in the path of flow of said fluid for directing the flow of said fluid so that it will flow in generally helical paths along the interior walls of said tubes, said tubes being provided with centrally disposed passageways for discharge of said fluid flows; and means establishing a path of flow for another fluid over the exteriors of said tubes in heat exchange relationship with the fluid flowing through the interiors thereof.

4. A heat exchanger comprising: walls defining a plenum chamber; a first duct communicating with said chamber; a plurality of vortex tubes, each closed at one end and having inlet and outlet openings at the other end, each of said tubes extending through said chamber with said closed end and one of said openings of each of said tubes disposed exteriorly thereof, the other of said openings of each of said tubes being located within said plenum chamber; a second duct communicating with said one of said openings of each of said vortex tubes, whereby paths of flow for a fluid are established between said first and second ducts and including the interiors of said tubes; and means establishing a path of flow for another fluid over the exteriors of said tubes in heat exchange relationship with the fluid flowing through the interiors thereof.

5. A heat exchanger, comprising: walls defining a plenum chamber; a first duct communicating with said chamber; a plurality of heat exchange tubes, each having one end open and the other end closed, said tubes extending through said chamber with their ends disposed exteriorly thereof; a second duct communicating with

said open ends of said tubes; passageways through the walls of said tubes providing communication between said plenum chamber and the interiors of said tubes, and thereby establishing paths of flow for a fluid between said first and second ducts, said paths including the interiors of said tubes; and means establishing a path of flow for another fluid over the exteriors of said tubes in heat exchange relationship with the fluid flowing through the interiors thereof.

6. A heat exchanger comprising: walls defining a plenum chamber; a first duct communicating with said chamber; a plurality of heat exchange tubes, each having one end open and the other end closed, said tubes extending through said chamber with their ends disposed exteriorly thereof; a second duct communicating with said open ends of said tubes; passageways through the walls of said tubes providing communication between said plenum chamber and the interiors of said tubes, and thereby establishing paths of flow for a fluid between said first and second ducts, said paths including the interiors of said tubes; means for directing the flow of said fluid longitudinally along the interior walls of said tubes away from said plenum chamber, said fluid then returning toward said plenum chamber and passing out through said open ends of said tubes; and means establishing a path of flow for another fluid over the exteriors of said tubes in heat exchange relationship with the fluid flowing through the interiors thereof.

7. A heat exchanger comprising: a plurality of heat exchange tubes closed at one end; nozzle members connected to the opposite ends of said tubes having inlet openings for delivering into said tubes gaseous fluid, said nozzle members having outlet openings for the egress of gaseous fluid from said tubes; a plenum chamber connected to said inlet openings of said nozzle members; means for delivering gaseous fluid under pressure to said plenum chamber; duct means connected to said outlet openings; and means establishing a path of flow of another fluid over the exteriors of said tubes in heat exchange relation to the fluid flowing within the interiors thereof.

8. A heat exchanger comprising: a plurality of heat exchange tubes; nozzle means connected to one end of each of said tubes having inlet openings for delivering into said tubes gaseous fluid, said nozzle means having outlet openings for the egress of gaseous fluid from said tubes; a plenum chamber connected to said inlet openings of said nozzle means; means for delivering gaseous fluid under pressure to said plenum chamber; duct means connected to said outlet openings; and means establishing a path of flow of another fluid over the exteriors of said tubes in heat exchange relation to the fluid flowing within the interiors thereof.

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