Dec. 6, 1949 P. KOLLSMAN 2,490,067

THERMODYNAMIC MACHINE

Filed Aug. 27, 1945 2 Sheets-Sheet 1

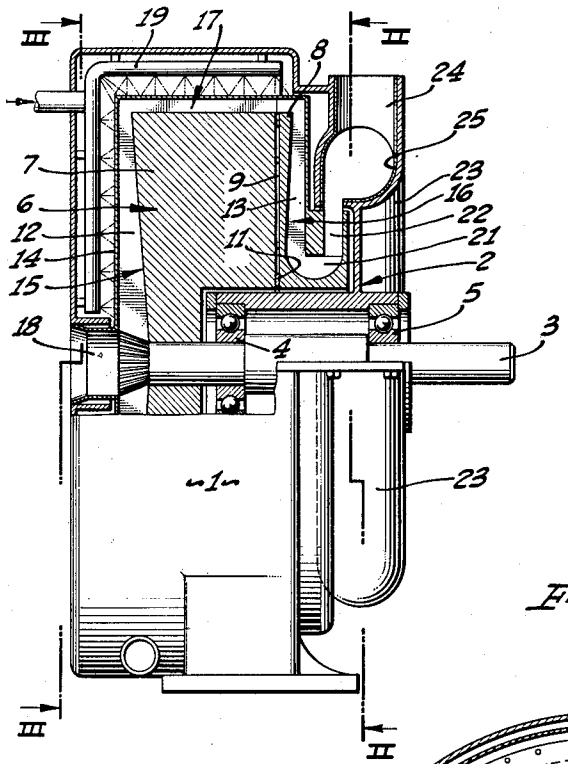


FIG. 1.

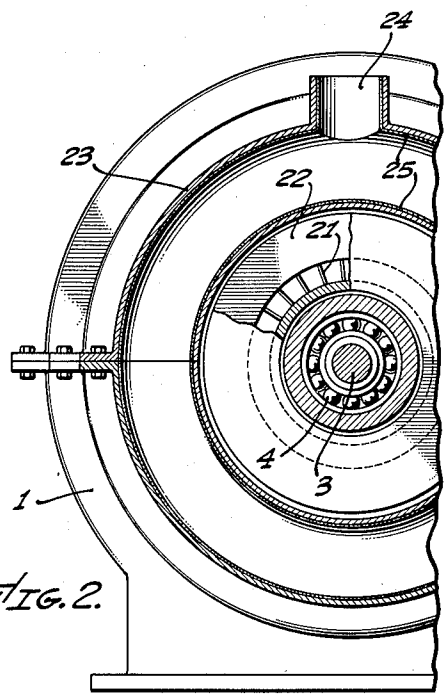


FIG. 2.

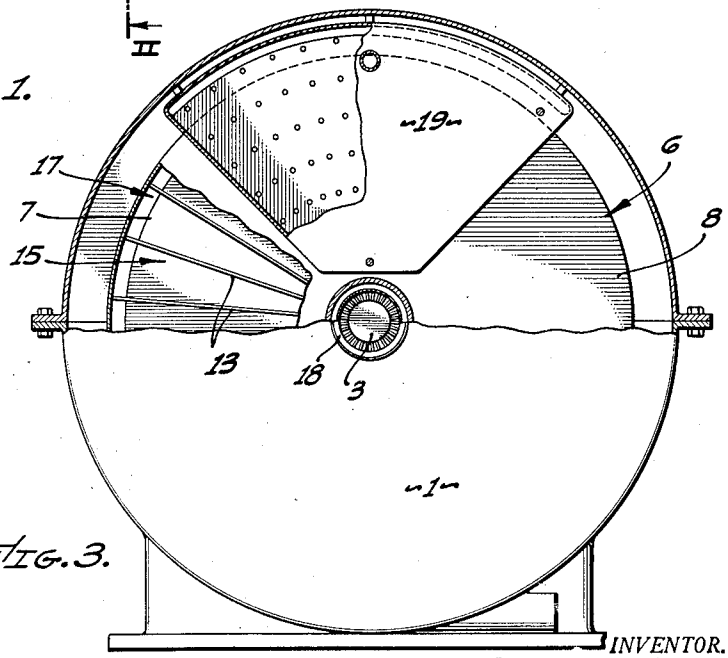


FIG. 3.

INVENTOR.
PAUL KOLLSMAN,
BY Mynon J. Seibold.
ATTORNEY.

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THERMODYNAMIC MACHINE

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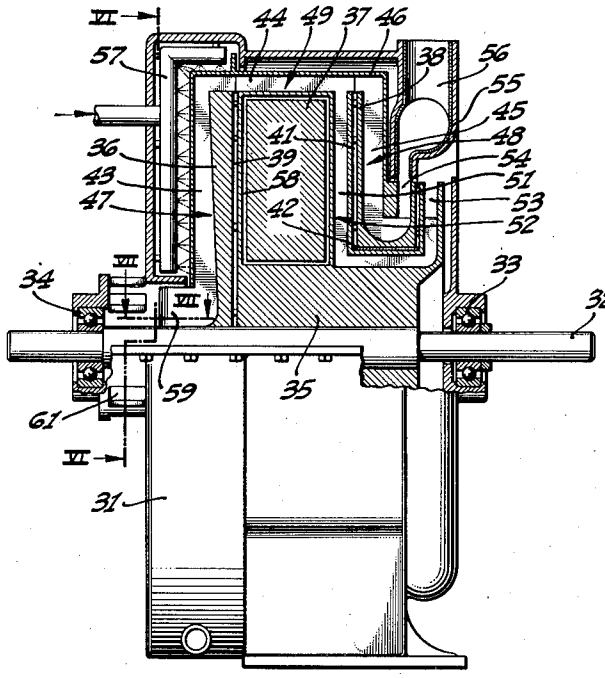


FIG. 4.

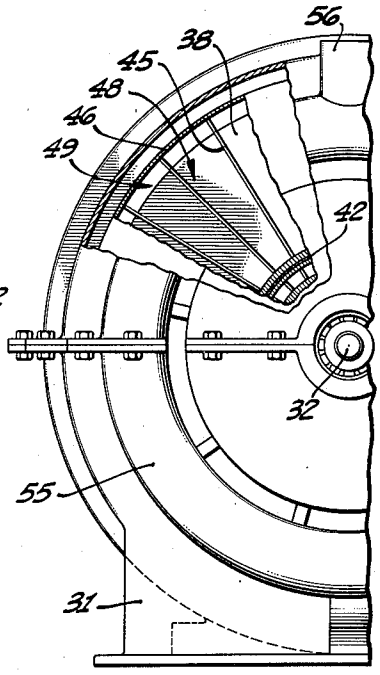


FIG. 5.

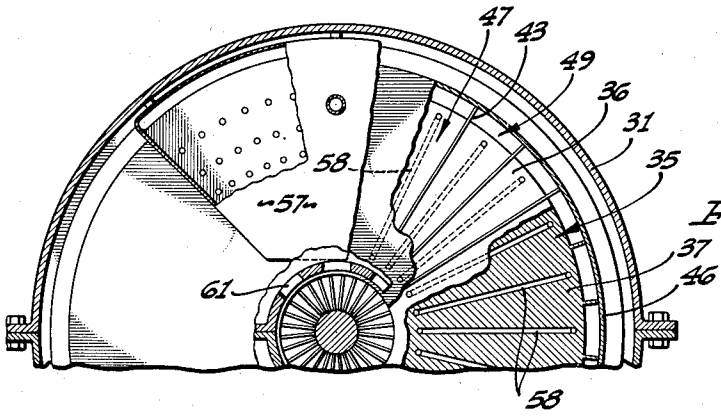


FIG. 6.

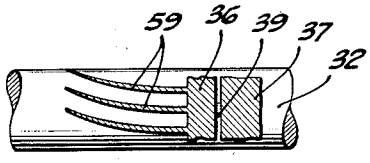


FIG. 7.

INVENTOR.
PAUL KOLLSMAN,
BY Myron J. Seibold
ATTORNEY.

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THERMODYNAMIC MACHINE

Paul Kollsman, New York, N. Y.

Application August 27, 1945, Serial No. 612,957

13 Claims. (Cl. 62—136)

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This invention relates to a thermodynamic machine for effecting cooling by passing air or gas through a compression-expansion cycle with absorption of the heat of compression.

One object of the invention is the provision of a thermodynamic machine in which a gas is rotated while passing in a generally U-shaped path to effect compression of the gas adjacent to the bight of the U with absorption of the heat of compression and in which the expanded gas is discharged from the machine.

Another object of the invention is a thermodynamic machine in which a gas is rotated at high velocity while moving in a substantially U-shaped path to effect compression of the gas toward the bight of the U, with absorption of the heat of compression, and with the flow of gas through the passage effected by the difference in the lengths of the legs of the path.

Another object of the invention is a thermodynamic machine in which air is rotated in a U-shaped passage to effect compression toward the bight of the U, with absorption of the heat of compression, and with the collected, expanded air delivered to a diffuser passage where the conversion of its rotational energy assists the flow through the U-shaped passage.

Other objects and features of the invention will be readily apparent to those skilled in the art from the specification and appended drawing illustrating certain preferred embodiments in which:

Figure 1 is a view, partly in section and partly in elevation, of a thermodynamic machine according to the present invention.

Figure 2 is a partial sectional view on the line II—II of Figure 1 with parts shown on other sections and in elevation.

Figure 3 is a partial sectional view on line III—III of Figure 1.

Figure 4 is a view partly in section and partly in elevation of a modified form of the elevation.

Figure 5 is an end elevational view with portions broken away to show internal parts.

Figure 6 is a partial sectional view on the line VI—VI of Figure 4.

Figure 7 is a detail sectional view on the line VII—VII of Figure 4.

In the form of the invention illustrated in the Figures 1, 2, and 3, there is provided an outer casing 1 carrying a stationary internal cylindrical portion 2 within which is rotationally mounted a shaft 3 on bearings 4 and 5. Upon the inner end of the shaft 3 is mounted a rotor generally indicated at 6 which is comprised of two sections

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7 and 8 joined together in spaced relation to provide an insulating space 9 there-between, the inner portion of the space 9 being closed by a solid insulating seal 11. Upon the rotor sections 7 and 8 are mounted a plurality of fins 12 and 13, circumferentially spaced about the rotor. At the exterior of the fins 12 and 13 is a casing 14 rigidly secured thereto and rotating therewith and with the rotor sections 7 and 8. The fins 12 and 13 divide the space between the outer rotor casing 14 and the inner rotor sections 7 and 8 into a plurality of generally U-shaped chambers having substantially radially extending legs 15 and 16 and axially extending bights 17. An air inlet to the chamber legs 15 is indicated at 18 at the axis of the machine.

Within the casing 1 is disposed a sprayer 19 extending along a side and the periphery of the rotary casing 14 and serving to spray cooling water upon the surface of the casing to absorb the heat of compression of the air. The casing 14 is of relatively thin section and preferably formed of a material effecting heat transfer with high efficiency.

The rotor fins 13 have portions 21 at the end of chamber leg 16 serving to direct the cooled and expanded air into a diffuser passage 22 formed by parallel annular walls of the rotor, shown as integral with the section 8 and the casing 14. From diffuser passage 22 the air passes to a collector ring 23 and thence to a discharge outlet 24. Heat insulation 25 is indicated on the walls of the collector ring 23 and the discharge outlet 24 to maintain the low temperature of the delivered air.

In the operation of the machine the shaft 3 is rotated from an external source of power and cooling water supplied to the sprayer 19 and thence into contact with the heat exchange walls of the casing 14. A flow of gas is effected through the U-shaped chambers or passages in the rotor from the inlet 18 through chamber leg 15, bight 17, chamber leg 13 to the air discharge. This flow is maintained by the difference in lengths of the legs 15 and 16 and the difference in the centrifugal force on the columns of air in these legs. This flow of air is also assisted by the action of the diffuser 22 in which the rotational energy of the air delivered to the diffuser is converted to pressure energy as the air moves to a greater radius of rotation therein. As the gas moves along the chamber leg 15 it is progressively compressed toward the bight 17 due to the action of centrifugal force on the air columns and the heat of compression of the air is absorbed by the

cooling water sprayed from the sprayer 19. As the gas returns toward the axis of the machine through the chamber leg 17 it will be progressively expanded and cooled so that the air delivered to the collector ring will be at a considerably lower temperature than at the intake 16.

Since the air in chamber leg 16 is at a lower temperature and density than the air in the chamber leg 15, the difference in the lengths of the chamber legs must be such so that combined with the force on the air in the diffuser 22 the desired movement through the U-shaped passages or chambers is secured at the desired air delivery temperature.

In the modification of the invention illustrated in Figures 4 through 7, there is provided a heat exchanger for further lowering the temperature of the delivered air. In this machine there is shown a casing 31 in which is rotationally mounted a shaft 32 in bearings 33 and 34. Upon the shaft 32 is mounted a rotor, generally indicated at 35, comprising three internal sections 36, 37, and 38 joined together in spaced relations to provide insulating spaces 39 and 41 therebetween, space 41 being provided with a solid insulating seal 42 to prevent air passage therethrough. The rotor sections are provided with fins 43, 44, and 45 spaced circumferentially about the rotor. Connected to the outside portions of the fins 43, 44, and 45 is a rotary casing 46, with the fins dividing the space between the casing 46 and the interior sections of the rotor into a plurality of substantially U-shaped chambers. These U-shaped chambers having substantially radially extending legs 47 and 48 and connecting bights 49.

Within the rotor section 37 there are provided a plurality of additional chambers communicating with the chamber bights 49 and disposed between fins or walls 51 in the rotor section. These chambers being generally L-shaped, as shown, with radially extending legs 52 from which axially and radially extending portions lead to a diffuser passage 53 formed between parallel walls on the rotor section and from which the air vents to the atmosphere. The radial chamber legs 48 communicate with a diffuser passage 54 from which the refrigerated air is delivered to a collector ring 55 having an outlet 56.

Within the casing 31 there is provided a sprayer 57 from which cooling water is sprayed upon the surfaces of the casing 46. Circumferentially spaced within the rotor section 37 are a plurality of closed passageways 58 containing water or other liquid to circulate as a heat transfer medium. The rotor fins 43 have axially extending portions 59 curved in the direction of rotation of the rotor to serve as scoops for directing air within the chamber legs 47. The air inlet is through the opening 61 in the hub on the casing 31.

In the operation of the machine of Figures 4 through 7 the shaft 32 is rotated from an external power source and cooling water is applied to the casing 46 from the sprayer 57. Air passes from the inlet at 61 through chamber or passage legs 47, bights 44, legs 48 and 52, to the diffusers 54 and 53, respectively. This flow of air is maintained by 3 factors, the scoop action of the fin portions 59, the difference in the lengths of the gas columns in the radially extending legs, and the action of the diffusers 53 and 54. Air passing outwardly through the legs 47 is compressed and its heat of compression is absorbed by the cooling water. Air passing inwardly through the legs 48 is collected as refrigerated air and that portion passing through the legs 52 is vented to the atmosphere.

As the expanding air in the chamber or passage legs 52 is cooled it absorbs heat from the righthand radial legs of the liquid in the closed passages 58. The columns of liquid in these legs have a greater density than in the opposite legs and due to the action of centrifugal force a circulation of the liquid is effected in a counterclockwise direction as viewed in Figure 4. The liquid in the axially extending legs of the closed passages 58 is in counter-flow, heat exchange relation with the compressed air within the bights 49 and serves to lower its temperature below the normal temperature obtained from the cooling water spray. Thus the air passing through the passage 48 will begin its expansion at an initially lower temperature with a consequent delivery of cooler air to the collector. With this heat exchange arrangement the temperature of the delivered air will be lowered but at the expense of the volume delivered since a portion of the air passing through the machine is exhausted to the atmosphere from the diffuser passage 53. The relative sizes of the chamber legs will determine the proportions of the air delivered and diverted and the temperature of the delivered air.

While the legs of the passages or chambers are referred to herein and in the appended claims as being radial, it will be understood that they may have any direction from the axis toward the periphery having a radial component.

While certain preferred embodiments of the invention have been specifically disclosed, it is understood that the invention is not limited thereto, as many variations will be readily apparent to those skilled in the art and the invention is to be given its broadest possible interpretation within the terms of the following claims.

What is claimed is:

1. In a thermodynamic machine, means providing a substantially U-shaped passage for gas flow, means for rotating said first mentioned means about an axis with the legs of the U extending substantially radially of the axis with the bight remote therefrom, the gas in said passage being progressively compressed toward the bight by the action of centrifugal force on the gas columns in the legs, means for absorbing the heat of compression of the compressed gas, the legs of said passage being of different lengths, a gas inlet adjacent to the longer passage leg, a gas outlet adjacent to the shorter passage leg, flow of gas through passage being maintained by the difference in centrifugal force on the different lengths of the gas columns in the legs.

2. In a thermodynamic machine, means providing a substantially U-shaped passage for gas flow, means for rotating said first mentioned means about an axis with the legs of the U extending substantially radially of the axis and with the bight remote therefrom, the gas in said passage being progressively compressed in the first leg of said passage leading toward the bight by the action of centrifugal force on the gas columns in the legs, means for absorbing the heat of compression of the compressed gas, a gas inlet adjacent to the end of the second leg of the passage, and a diffuser adjacent to the end of the second leg, said diffuser including a further U-shaped passage portion for changing the direction of the

cooled gas from a substantially radial inward direction to a substantially radial outward direction, conversion of the rotational energy of the gas in the diffuser promoting gas flow through said first named passage.

3. In a thermodynamic machine for refrigerating air, means forming a generally U-shaped passage for air flow, means for rotating said first mentioned means about an axis with the legs of the U extending substantially radially of said axis and with the bight remote therefrom, air in said passage being progressively compressed toward the bight of the U by the action of centrifugal force on the air columns in the legs, the legs of said passage being of unequal length, an air inlet for the end of the longer passage leg, and an outlet for refrigerated air from the shorter passage leg.

4. In a thermodynamic machine, a rotor, means providing a plurality of circumferentially spaced gas passages about said rotor with the legs of the passages extending substantially radially of the rotor and with their bights adjacent to the periphery of the rotor, the gas in said passages being progressively compressed toward the bights, said legs being of unequal length to establish a gas flow through the passages, and means for absorbing the heat of compression of the compressed gas whereby refrigerated gas will be delivered at the ends of the shorter passage legs.

5. In a thermodynamic machine, a rotor, means providing a plurality of circumferentially spaced gas passages about said rotor with the legs of the passages extending substantially radially of the rotor and with their bights adjacent to the periphery of the rotor, the gas in said passages being progressively compressed toward the bights, said legs being of unequal length to establish a gas flow through the passages, means for absorbing the heat of compression of the compressed gas whereby refrigerated gas will be delivered at the ends of the shorter passage legs, and a diffuser passage into which said refrigerated gas is delivered for conversion of its rotational energy to assist gas flow through the passages.

6. In a thermodynamic machine, a rotor, means providing a plurality of circumferentially spaced gas passages about said rotor with the legs of the passages extending substantially radially of the rotor and with their bights adjacent to the periphery of the rotor, the gas in said passages being progressively compressed toward the bights, said legs being of unequal length to establish a gas flow through the passages, means for absorbing the heat of compression of the compressed gas whereby refrigerated gas will be delivered at the ends of the shorter passage legs, and means for diverting a portion of the refrigerated gas to further lower the temperature of the compressed gas.

7. In a thermodynamic machine, a rotor, means providing a plurality of circumferentially spaced gas passages about said rotor with the legs of the passages extending substantially radially of the rotor and with their bights adjacent to the periphery of the rotor, the gas in said passages being progressively compressed toward the bights, said legs being of unequal length to establish a gas flow through the passages, means for absorbing the heat of compression of the compressed gas whereby refrigerated gas will be delivered at the ends of the shorter passage legs, and a heat exchanger in heat transfer relation with said compressed gas and means for expanding a portion of said compressed gas to cool said exchanger to cool the compressed gas to further lower the temperature of the delivered refrigerated gas.

8. In a thermodynamic machine, means providing the rotary axis, means providing a plurality of gas passages having legs extending substantially radially of said axis with a connecting bight portion remote from the axis, one of said legs being of greater length than two other of said legs, a gas inlet for the end of the longer leg, the gas in said bight being compressed by the action of centrifugal force on the columns of gas in the legs, means for absorbing the heat of compression of the compressed gas, gas outlets adjacent to the ends of the shorter legs, means for collecting the gas from one of said shorter legs, and means for cooling the compressed gas by the expansion of the gas in the other of said shorter legs.

9. In a thermodynamic machine, means providing the rotary axis, means providing a plurality of gas passages having legs extending substantially radially of said axis and with a connecting bight portion remote from the axis, one of said legs being of greater length than two other of said legs, a gas inlet for the end of the longer leg, the gas in said bight being compressed by the action of centrifugal force on the columns of gas in the legs, means for absorbing the heat of compression of the compressed gas, gas outlets adjacent to the ends of the shorter legs, means for collecting the gas from one of said shorter legs, a liquid in heat exchange relation with the gas expanding in the other of said shorter legs, and means for circulating said liquid in counter-flow heat exchange relation with the compressed gas to effect cooling thereof.

10. In a thermodynamic machine, means providing the rotary axis, means providing a plurality of gas passages having legs extending substantially radially of said axis, and with a connecting bight portion remote from the axis, one of said legs being of greater length than two other of said legs, a gas inlet for the end of the longer leg, the gas in said bight being compressed by the action of centrifugal force on the columns of gas in the legs, means for absorbing the heat of compression of the compressed gas, gas outlets adjacent to the ends of the shorter legs, means for collecting the gas from one of said shorter legs, a liquid in heat exchange relation with the gas expanding in the other of said shorter legs, and a closed path for said liquid having radial components and extending in heat exchange relation with the bight passage, circulation of the liquid to cool the compressed gas being effected by the action of centrifugal force on its different density portions.

11. In a thermodynamic machine, means providing the rotary axis, means providing a plurality of gas passages having legs extending substantially radially of said axis and with a connecting bight portion remote from the axis, one of said legs being of greater length than two other of said legs, a gas inlet for the end of the longer leg, the gas in said bight being compressed by the action of centrifugal force on the columns of gas in the legs, means for absorbing the heat of compression of the compressed gas, gas outlets adjacent to the ends of the shorter legs, means for collecting the gas from one of said shorter legs, a liquid in heat exchange relation with the gas expanding in the other of said shorter legs, and a closed path for said liquid

having radial components and extending in heat exchange relation with the bight passage, circulation of the liquid to cool the compressed gas being effected by the action of centrifugal force on its different density portions, the liquid movement being in counter-flow relation with the movement of gas through the passages effected by the action of centrifugal force on the different length gas columns in the passage legs.

12. In a thermodynamic machine, means establishing substantially U-shaped passage for gas flow, means for rotating said first mentioned means about an axis with the legs of the U disposed substantially radially of the axis and the bight remote therefrom, the gas in said passage being progressively compressed toward the bight under the action of centrifugal force on the gas columns in the legs, means for absorbing the heat of compression of the compressed gas, said legs being of different lengths, a gas inlet adjacent to the end of longer leg, a gas outlet adjacent to the end of shorter leg and a blade at the end of said longer passage leg for scooping gas into the passage.

13. In a thermodynamic machine, means establishing a substantially U-shaped passage for gas flow, means for rotating said first mentioned means about an axis with the legs of the U disposed substantially radially of the axis and with the bight remote therefrom, the gas in said passage being progressively compressed toward the bight under the action of centrifugal force on the gas columns in the legs, means for absorbing the heat of compression of the compressed gas, said legs being of different lengths, a gas inlet adjacent to the end of longer leg, a gas outlet adjacent to the end of the shorter leg and a blade at the end of said longer passage leg for scooping gas into the passage, said outlet comprising a diffuser passage in which the rotational energy of delivered gas is converted to assist the gas flow produced by said blade and unequal passage leg lengths.

PAUL KOLLSMAN.

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