June 22, 1937. R. D. BOOTH ET AL 2,084,474

TURBINE STRUCTURE

Filed Sept. 8, 1932 2 Sheets-Sheet 1

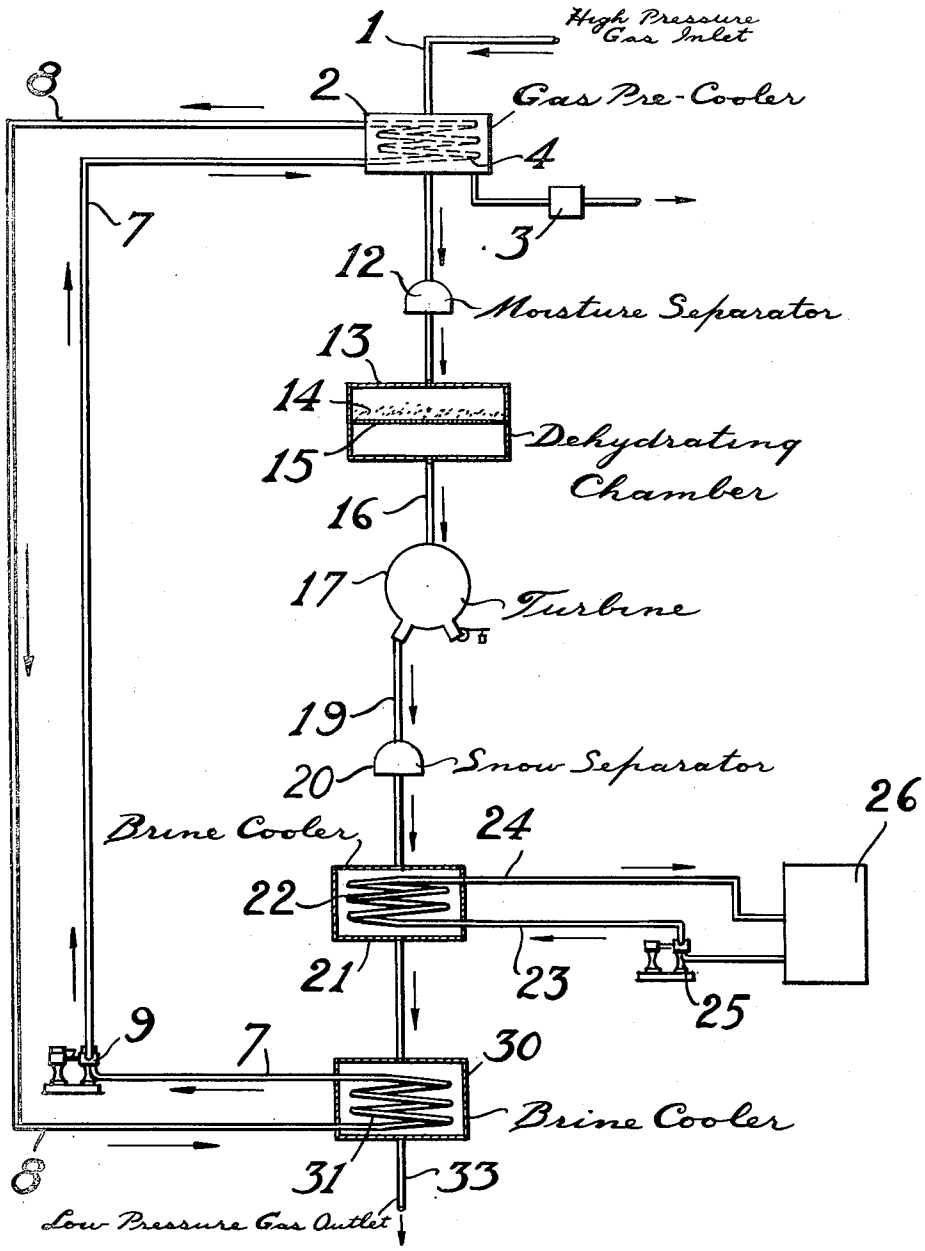


Fig. — 1

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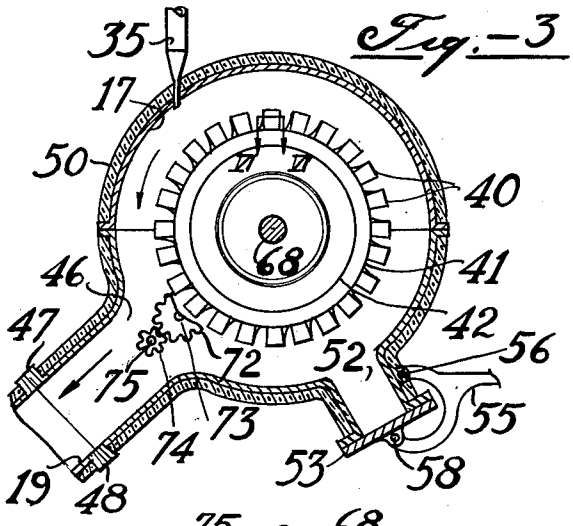
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TURBINE STRUCTURE

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Fig.-3



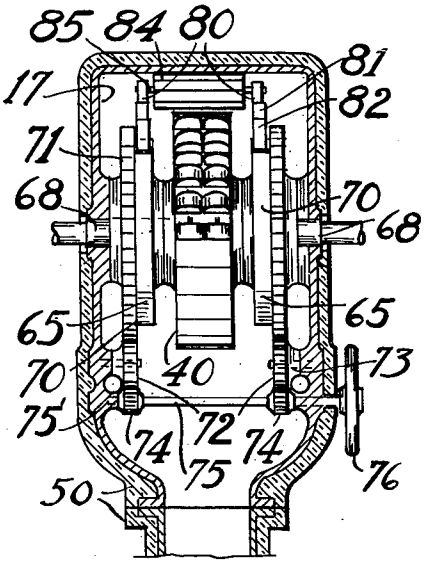
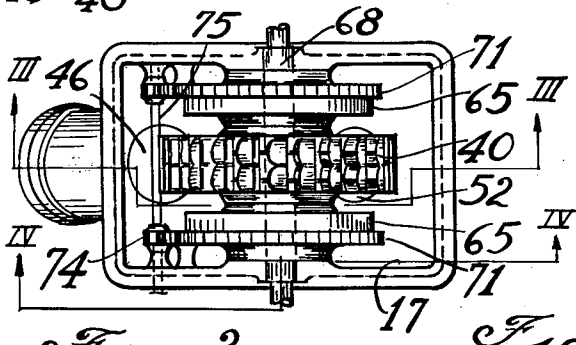


Fig.-5



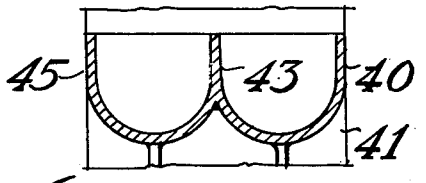


Fig.-2

Fig.-6

Fig.-7

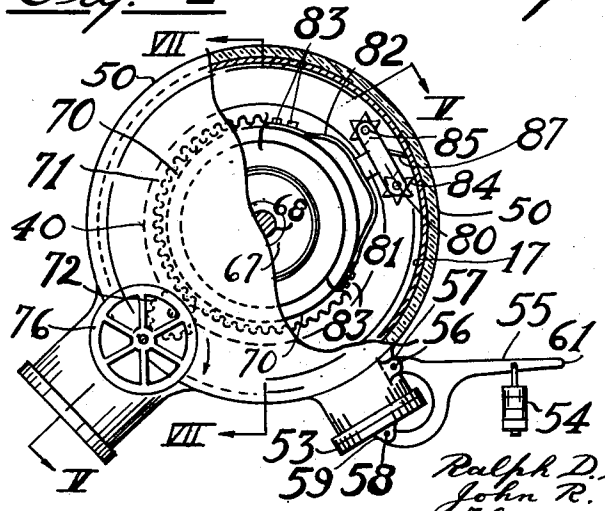
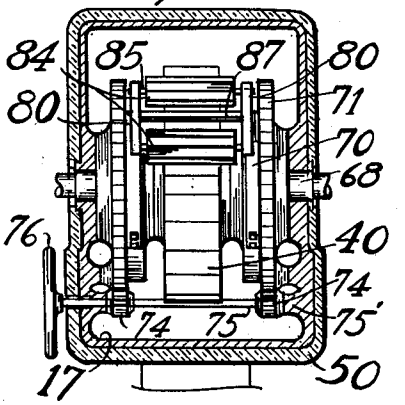


Fig.-4



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Patented June 22, 1937 2,084,474

UNITED STATES PATENT OFFICE

2,084,474

TURBINE STRUCTURE

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Application September 8, 1932, Serial No. 632,140

9 Claims. (Cl. 62—136)

This invention relates to improvements in the design and use of a turbine operable by the expansion of a gas from a higher to a lower pressure and designed to avoid difficulties arising from the accumulation and building up of deposits of fine snow and/or frost within the turbine.

The invention will be fully understood from the following description taken in connection with the accompanying drawings in which latter—

Fig. 1 is a flow diagram indicating the arrangement of a turbine and the various items of equipment for pre-cooling the gas and removing the precipitated moisture for reducing the humidity of the gas before expansion and for utilizing the refrigeration available from the expanded gas.

Fig. 2 is upper housing removed showing the plan or top view of turbine.

Fig. 3 is a cross section of turbine taken on line III—III of Fig. 2.

Fig. 4 is elevation and section of turbine taken on line IV—IV of Fig. 2.

Fig. 5 is longitudinal section of turbine taken on the line V—V of Fig. 4.

Fig. 6 is a section of bucket taken on line VI—VI of Fig. 3.

Fig. 7 is a section and elevation of turbine taken on the line VII—VII of Fig. 4.

Referring particularly to Fig. 1, high pressure gas is conveyed by a pipe 1 to a gas pre-cooler 2 equipped with a trap 3 and containing a pipe coil 4 in which cold brine is caused to be circulated from a cold brine header 7 to a warm brine header 8 by a pump 9. The gas passing over the pipe coil 4 is chilled and a part of its moisture is precipitated and ejected from the gas pre-cooler through the trap 3. The cold gas passes from the pre-cooler 2 to a moisture separator 12 which may be any one of a number of familiar types and the function of which is to remove any precipitated moisture which has been swept through the pre-cooler 2. In some cases it may be desirable to omit the gas pre-cooler 2 and the moisture separator 12. The effect of pre-cooling the gas is to give a lower temperature available for refrigeration in the expanded gas than would otherwise be the case and also to reduce the amount of moisture precipitated as snow or frost within the turbine. Therefore, the desirability of using the pre-cooler 2 would depend upon the circumstances of each case as explained below.

From the moisture separator 12 the gas passes to a dehydrating chamber 13 containing any suitable de-hydrating substance 14 such as calcium chloride supported by a screen 15. The dehydrating substance 14 absorbs a portion of the moisture vapor present in the gas and the gas thus partially dried is conveyed by a pipe 16 to a turbine 17, in which it expands, furnishing power to the turbine which drives an electric generator or other suitable device not shown. As explained below hereof, the dehydrating equipment would not be required in all cases, but is included in this description in order that the disclosure may be complete. Within the turbine 17 the precipitation of moisture as frost or snow takes place without interfering with the operation of the turbine for the reasons explained above.

By a pipe 19 the cold expanded gas passes from the turbine 17 to a snow separator 20 which may be any one of a number of familiar types and the function of which is to remove the snow and frost which may have been swept through the turbine 17. In some cases there may be no objection to allowing the snow to remain in the gas in which case the snow separator 20 would be omitted. From the snow separator 20 the gas passes to a brine cooler 21 containing a pipe coil 22 in which brine is caused to circulate from a warm brine header 23 to a cold brine header 24 by a pump 25. The cold brine header 24 conveys the brine to any apparatus adapted to use it for refrigerating purposes. This apparatus, which has been indicated as 26, might well be a brine cooled ice freezing tank such as is commonly used in the manufacture of ice. After its refrigerating purpose has been accomplished the brine is returned through the warm brine header 23 to be recooled in pipe coil 22 as previously described. Obviously any other suitable circulating medium could be used in place of brine. Or if the substance to be refrigerated is of suitable characteristics it could be circulated directly in the pipe coil 22.

The gas passes from the brine cooler 21 to a second brine cooler 30 containing a pipe coil 31 in which brine is caused to circulate from the warm brine header 8 to the cold brine header 7 by the pump 9. The gas which is still cold, chills the brine in the pipe coil 31 which then passes by the cold brine header 7 to the pipe coil 4 in the gas pre-cooler 2 where it pre-cools the high pressure gas as previously described. From the brine cooler 30 the gas is conveyed by a pipe 33 to the low pressure distribution system, not shown, for use as a fuel or other purposes. In some cases it may be desirable to locate the brine cooler 30 between the snow separator 20 and the brine cooler 21 thereby utilizing the low-

est temperature available for pre-cooling, or it may be desirable to eliminate brine cooler 30 and utilize the brine from pipe coil 22 for pre-cooling.

Referring particularly to Figs. 2–7 inclusive in which the turbine structure is illustrated, high pressure gas is conducted by the pipe 16 to a nozzle 35 fixed in the turbine casing 17. The inside of the turbine casing 17 is in communication by the exhaust pipe 19 with the low pressure distribution system and therefore the pressure inside the turbine casing 17 is approximately at the same value as in the low pressure distribution system. The gas passing through the nozzle 35 expands to the lower pressure within the casing and thereby acquires a high velocity. At the same time the gas temperature is reduced and the moisture vapor contained therein is precipitated in the form of finely divided frost or snow. The gas stream at high velocity impinges on buckets 40 which are secured to rim 41 of a turbine rotor 42. Each bucket 40 is divided by a central fin 43 as in Fig. 6 so that the bucket has the section form of a W. The gas jet is separated by the central fin 43 into two portions which sweep around the interior of the bucket and are discharged at outer fins 45. The action of the gas stream is substantially equivalent to the action of a stream of water in the familiar Pelton type of water wheel.

The gas stream having caused the turbine rotor 42 to revolve is deflected from the buckets into the body of the turbine casing 17 and passes out of the casing through an exhaust port 46 to which is connected the exhaust pipe 19 by means of flanges 47 and 48. The cold exhaust gas may be conducted by the exhaust pipe 19 directly to a low pressure distribution system if desired. The turbine rotor 42 carrying the buckets 40 on its rim 41 is so proportioned with respect to the casing 17 that there is at every point a generous clearance between the moving and the stationary parts. The turbine casing 17 and the exhaust pipe 19 are suitably protected by a heavy layer of heat insulating material 50. It is therefore seen that all parts of the interior of the turbine will be at substantially the same low temperature as the expanded gas issuing from the nozzle 35. Under ordinary conditions of operation this temperature will be much below the freezing point of water and therefore all precipitated moisture will be in the form of a fine dry frost or snow which will not adhere to the interior of the turbine casing and the pipes and which will be thrown off of the turbine rotor 42 and the rotating buckets by the powerful centrifugal force resulting from the high rotating speed. The action of the powerful gas currents within the turbine casing 17 will assist in preventing the fine dry frost or snow from adhering either to the moving or the stationary parts of the turbine. Therefore, the frost will be swept out of the turbine casing with the exhaust gases through the exhaust port 46 and the exhaust pipe 19.

To provide for the removal of any frost or snow which is not swept out of the exhaust port 46 a settling chamber 52 is provided. This settling chamber is formed into the turbine casing 17 and is normally closed by a cover 53 which is held in position by a weight 54 acting on a lever 55 which is hinged by a pin 56 at a boss 57 formed on the turbine casing 17 and which also has a hinged connection with the cover 53 by means of pin 58 acting on a boss 59 formed on the cover 53. On account of its position at the lower part of the turbine casing the settling chamber 52 will receive whatever portion of the fine dry frost or snow is not swept out of exhaust port 46 along with the exhaust gases. The lever 55 is provided with a handle 61 which may be raised from time to time thereby opening the cover 53 and allowing the snow which has accumulated in the settling chamber 52 to be blown out by the pressure within the turbine casing which is maintained at a value somewhat above atmospheric. If desired, the gas and snow discharged from the settling chamber 52 may be piped to a suitable receiver in which the snow can be melted by heat from atmospheric or other sources and from which the gas may be drawn for use as a fuel or otherwise.

It will be noted from the figures and from the foregoing description that the turbine described is designed to avoid all close clearances and all irregularities in which the frost or snow can build up accumulations which would interfere with the proper operation of the turbine.

Any accumulation of ice or snow forming within the casing 17 is removed by the following arrangement of parts. Wheels 65 are mounted between the ends of the turbine rotor 42 and each end of the turbine casing 17. The wheels 65 are free to rotate on annular internal projections 67 of the turbine casing 17 which projections surround the turbine rotor shaft 68. Each wheel 65 carries on its rim 70 a gear 71 which meshes with an idler 72 which rotates on a pin 73 fixed in the turbine casing 17. The idler 72 is driven by spur gears 74 carried on a shaft 75 which rotates in a bearing 75' in the turbine casing 17 and is driven by a hand wheel 76, or in place of hand wheel 76 there could be provided other driving means such as an electric motor. The wheel 65, the idler 72 and the spur gears 74 are each duplicated at the two ends of the turbine casing. The spur gears 74 are keyed to the shaft 75 and therefore rotate together preserving a fixed angular relation between the two wheels 65 at the opposite ends of the turbine casing 17.

A yoke 80 is supported on the rim 70 of the wheel 65 by a block 81 and spring 82 which is attached to the rim 70 by means of bolts 83. The spring 82 is slotted to receive the bolts 83 and is therefore free to slide slightly on the rim 70 and thereby to apply a substantially constant outward force on the yoke 80. The yoke 80 carries at each extremity a toothed wheel 84 which is free to revolve on a pin 85. These toothed wheels are pressed against the turbine casing and when the wheel 65 is rotated through the gears 72 and 74 by turning the hand wheel 76, the toothed wheels 84 engage the interior of the turbine casing 17 and roll thereon, thereby breaking up any accumulation of ice or snow adhering to the interior of the turbine casing. The yoke 80 also carries approximately midway between the toothed wheels 84 a knife 87 the edge of which engages the interior of the turbine casing 17 and scrapes off the snow or ice which has been cracked and broken by the toothed wheels 84. Ordinarily the hand wheel 76 would be turned in such a direction as to cause the wheel 65 to rotate in a clockwise direction as viewed in Fig. 4; that is, in a direction opposite to the rotation of the turbine rotor. In this direction of rotation the powerful gas currents in the turbine casing would tend to clear the knife 87 from any accumulation of ice on its working face. Obviously, however, the apparatus could be arranged for rotation in the same direction as the turbine rotor, in which

case the gas currents within the casing would assist the rotation of the apparatus.

In ordinary operation the hand wheel **76** would be operated intermittently as frequently as experience proved desirable. When not being operated the hand wheel would be turned to such a position that the yoke **80** with the toothed wheels **84** and the knife **87** would occupy a position adjacent to the spur **74** and in this position the current of gas rushing out of the exhaust port would keep the yoke **80** and its associated equipment clear of any accumulation of ice and snow.

By the construction described the expansion of a gas containing moisture can be used as a means of obtaining power and refrigeration without detrimental frost formation while obtaining temperatures of the expanded gas sufficiently low to be of general refrigerating value. The turbine is so constructed that the fine snow and frost which form from moisture precipitated during the low temperature expansion of a moist gas do not accumulate within the turbine casing and build up in such a way as to interfere with the proper operation of the various parts of the turbine. The turbine is provided with generous clearances between stationary and movable parts and is provided with a smooth interior surface offering no place of lodgment for the precipitated snow and frost except a specially provided settling chamber from which the snow or frost can be readily removed. Special means are provided whereby without interference with operation of the turbine any snow or frost which may adhere to the inner surface of the turbine casing may be periodically removed. By the construction described the gas may be treated prior to its expansion within the turbine in such a way as to remove a portion of the moisture.

In some cases the conditions of expansion and the initial humidity and temperature of the gas may be such as to cause precipitation of moisture at temperatures both above and below the freezing point of water or in proximity thereto in which case the snow or frost formed thereby will be of an unusually moist and sticky nature, and therefore more likely to adhere to the turbine casing and turbine rotor than would otherwise be the case. To avoid this difficulty means are provided either for pre-cooling the gas and removing the precipitated moisture or for reducing its relative humidity, or both, prior to expansion so that further precipitation will not occur until the temperature reached is considerably below freezing, thereby preventing the formation of a moist sticky snow or frost. By this means such snow or frost as are precipitated are in a dry state and not inclined to adhere to the surfaces of the turbine.

Various changes may be made within the scope of the appended claims in which it is desired to claim all novelty inherent in the invention as broadly as the prior art permits.

We claim:

1. A turbine, comprising a casing having an inlet for high pressure gas and an outlet for expanded gas, a rotor within the casing adapted to be actuated by the gas, and means for removing frozen particles adhering to the inner surfaces of the casing.

2. A turbine according to claim 1 in which means are provided externally of the casing for operating the means for removing frozen particles from the inner surface of the turbine casing.

3. A turbine, comprising a casing having an inlet for high pressure gas and an outlet for expanded gas, a rotor within the casing adapted to be actuated by the gas, a frame rotatably mounted within the casing laterally of the rotor, rolls carried by the frame, and means operable from the exterior of the casing for rotating the frame whereby the rolls are caused to break and dislodge any frozen particles adhering to the casing.

4. A turbine, comprising a casing having an inlet for high pressure gas and an outlet for expanded gas, a rotor within the casing adapted to be actuated by the gas, a frame rotatably mounted within the casing, scraper plates carried by the frame adapted to engage the inner surfaces of the casing, and means for rotating the frame whereby the plates remove any frozen particles adhering to the said surfaces.

5. A turbine, comprising a casing having an inlet for high pressure gas and an outlet for expanded gas, a rotor within the casing adapted to be actuated by the gas, a plurality of wheels rotatably mounted within the casing co-axially with the rotor, means carried by the wheels for engaging the inner surfaces of the casing, and means operable from the exterior of the casing for rotating the wheels whereby any frozen particles accumulated upon the inner surfaces of the casing are broken up and removed by the first means.

6. A turbine comprising a casing having an inlet for high pressure gas and an outlet for expanded gas, a rotor within the casing adapted to be actuated by the gas, a frame mounted for rotation within the casing co-axially with the rotor, crushing rolls and scraper plates carried by the frame adapted to engage the inner surfaces of the turbine casing and dislodge any frozen particles accumulated thereon, a settling chamber in the lower portion of the casing adapted to receive frozen material, and a cover for the chamber adapted to be opened whereby frozen material accumulating in the chamber can be blown from the chamber.

7. A turbine, comprising a casing having an inlet for high pressure gas and an outlet for expanded gas, a rotor within the casing adapted to be actuated by the gas, the non-rotating parts of the turbine being spaced from the rotor in its working position to provide rotational clearance between encrustations of snow or ice, and a lining of heat insulating material for the casing whereby the interior of the casing is maintained at substantially the temperature of the expanded gas issuing from the inlet.

8. A turbine, comprising a casing having an inlet for high pressure gas and an outlet for expanded gas, the rotor within the casing adapted to be actuated by the gas, the rotor being spaced from the casing sufficiently to maintain a space between the rotor and any frozen particles accumulating upon the inner surface of the casing, a settling chamber in the lower portion of the casing adapted to receive frozen material from the gas, a cover for the chamber adapted to be opened whereby the frozen material accumulating in the chamber can be blown from the chamber, a frame within the casing mounted for rotation coaxially with the rotor, and crushing rolls carried by the frame adapted to engage the inner surfaces of the casing and dislodge any frozen particles accumulated upon the casing.

9. A method of obtaining power and refrigeration by the expansion of a moisture-containing compressed gas, comprising cooling and dehydrating said gas, expanding the gas and directing the expanded gas against the rotatable element

of a turbine while maintaining the interior of said turbine at a temperature below the freezing point of water, precipitating residual moisture as a dry snow during expansion of the gas, removing said precipitated residual moisture from the turbine and from the system and passing the substantially dry low temperature gas into heat exchanging relation with a fluid medium.

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