United States Patent [19]

Zara et al.

[11] **3,874,188**

[45] **Apr. 1, 1975**

[54] **AIR CYCLE COOLING SYSTEM WITH ROTARY CONDENSING DEHUMIDIFIER**

[75] Inventors: **Eugene A. Zara**, Dayton; **Lawrence L. Midolo**, Centerville; **William C. Savage**, Xenia, all of Ohio

[73] Assignee: **The United States of America as represented by the Secretary of the Air Force**, Washington, D.C.

[22] Filed: **May 9, 1974**

[21] Appl. No.: **468,326**

[52] **U.S. Cl.** **62/272**, 62/93, 62/150, 62/402

[51] **Int. Cl.** **F25d 21/00**

[58] **Field of Search** 62/93, 150, 272, 172

[56] **References Cited**

UNITED STATES PATENTS

2,586,002	2/1952	Carson	62/150
2,943,460	7/1960	Brown	62/272
2,979,916	4/1961	Mason	62/172
3,222,883	12/1965	Glaspie	62/93
3,623,332	11/1971	Fernandes	62/172

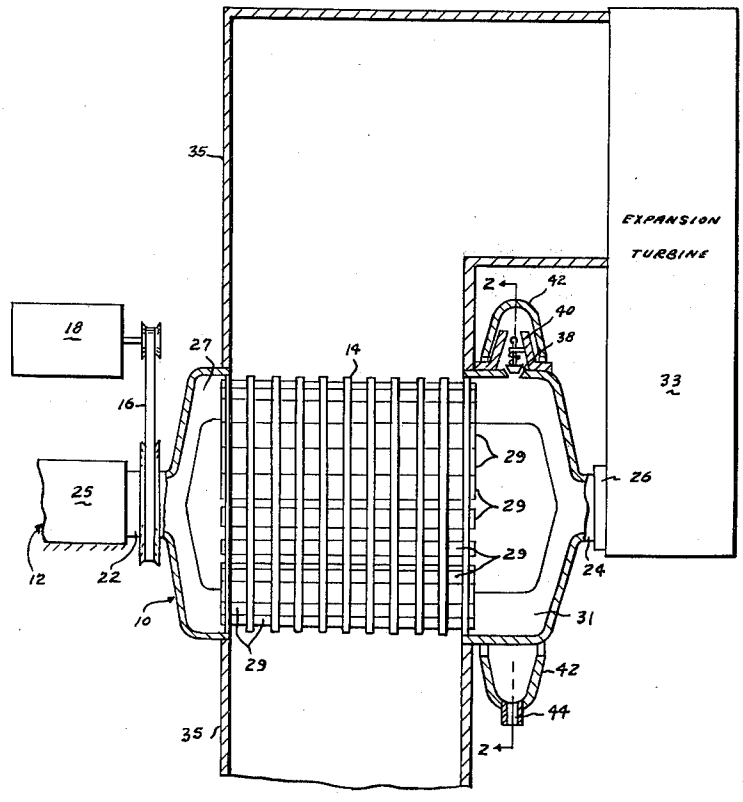
Primary Examiner—William J. Wye

Attorney, Agent, or Firm—Harry A. Herbert, Jr.; Richard J. Killoren

[57] **ABSTRACT**

An air cycle cooling system having a rotary condensing dehumidifier wherein the air from the compressor is passed through the vanes of a transverse flow heat exchanger with the cooled air from the expansion turbine being passed over the external surfaces of the vanes to thereby cool the air within the vanes. The cooling of the air within the vanes causes the moisture to be condensed. The water in the vanes is moved along with the moving air by viscus interaction. The water collects in the end member of the transverse flow heat exchanger and is removed by centrifugal force through poppet valves.

3 Claims, 3 Drawing Figures



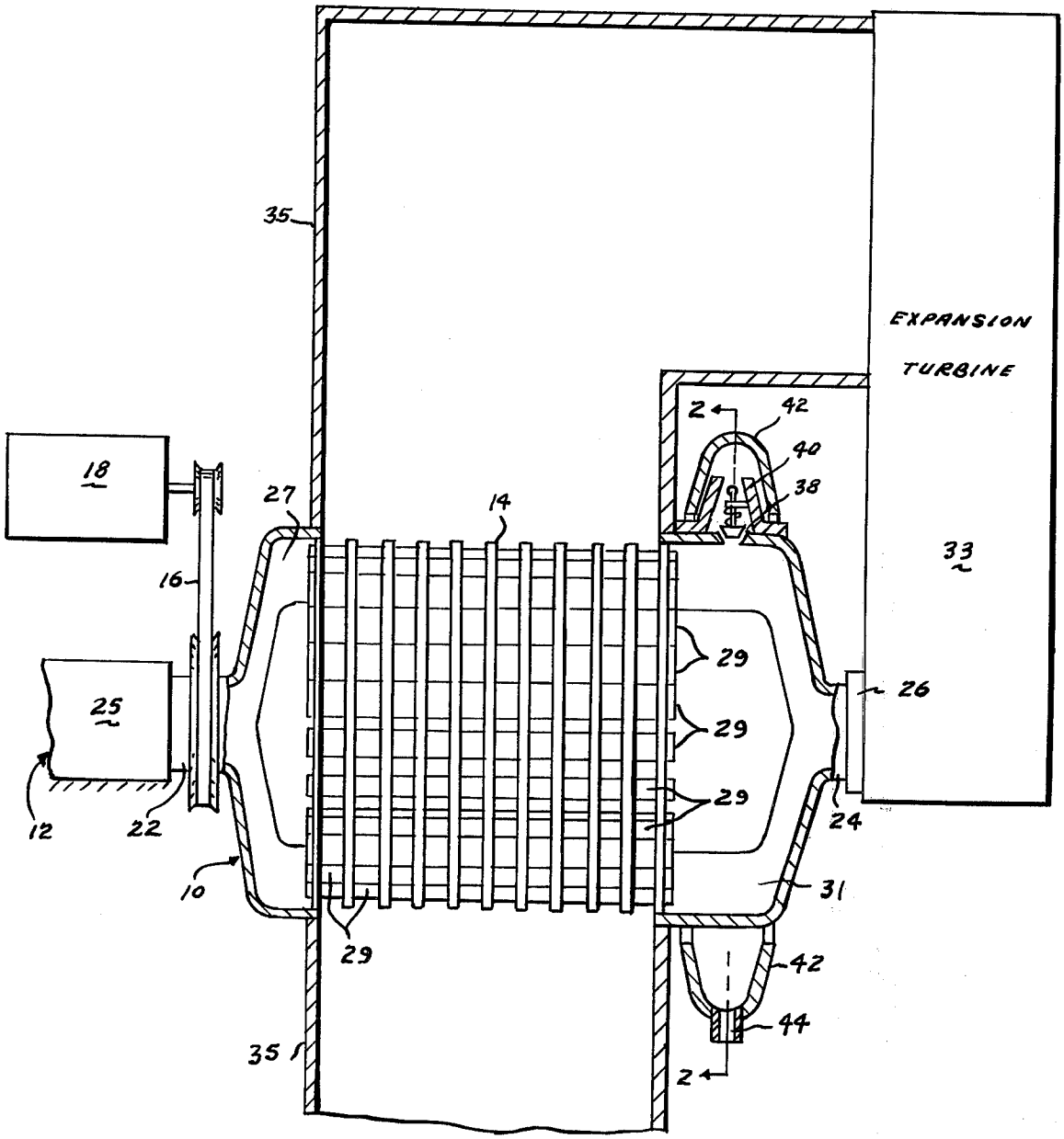

35
EXPANSION
TURBINE
2
42
40
38
18
27
14
33
16
29
29
25
26
29
12
22
24
10
31
29
42
44
35
2

Fig-1

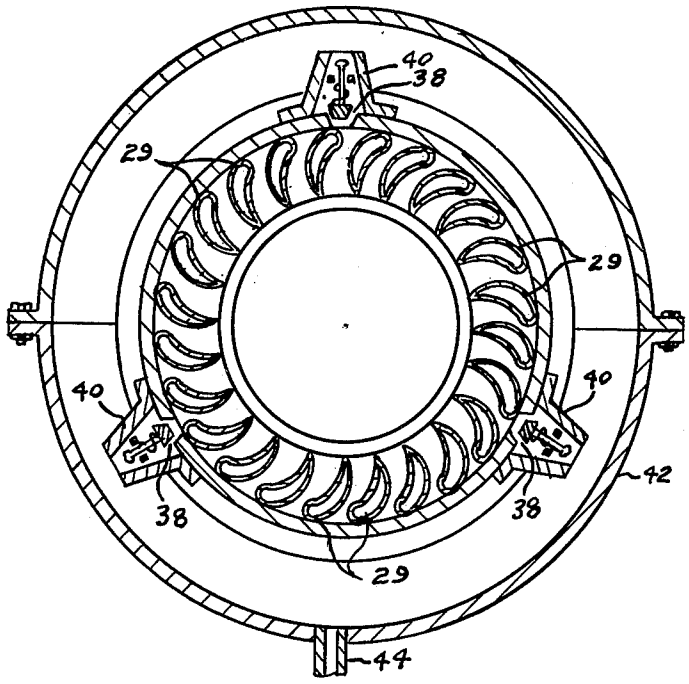


Fig-2

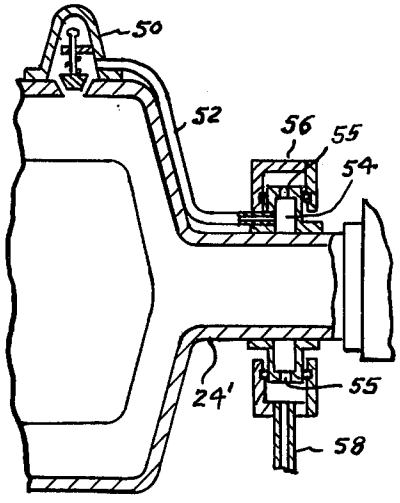


Fig-3

AIR CYCLE COOLING SYSTEM WITH ROTARY CONDENSING DEHUMIDIFIER

The invention described herein may be manufactured and used by or for the Government of the United States for all governmental purposes without the payment of any royalty.

BACKGROUND OF THE INVENTION

In air cycle cooling systems for aircraft, it is desirable to increase the cooling capacity of such systems to thereby reduce their weight and size for a given aircraft. The patent to Carson et al, U.S. Pat. No. 2,586,002, shows one type of air cycle cooling system for aircraft. In this system, the cooled expanded air from the expansion engine is passed across a swirl chamber which cools and removes water from the input air to the expansion engine. A more efficient cooling system for the input air to the expansion engine would provide drier air which could be expanded to a lower temperature thus increasing the cooling capacity of the system.

BRIEF SUMMARY OF THE INVENTION

According to this invention, a conventional two phase heat exchanger, wherein a liquid normally is passed through the hollow blades of an impeller with a cooling gas being passed over the blades of the impeller to thereby cool the liquid, is used with air passing through the hollow blades to thereby provide more efficient cooling of the air within the blades. The condensed water in the blades is moved axially within the blade passages by the air passing through the blades. The water is centrifuged to the outer wall of the exit manifold of the heat exchanger and is passed out of the manifold through poppet values to an external water recovery system. The dry air passes to the air cycle expansion turbine and over the outer portion of the heat exchanger and then to the aircraft cabin.

IN THE DRAWING

FIG. 1 is a partially cut away view of an air cycle cooling system with a condensing dehumidifier according to the invention.

FIG. 2 is a sectional view of the device of FIG. 1 along the line 2—2.

FIG. 3 shows a modified water extraction apparatus for use with the device of FIG. 1.

DETAILED DESCRIPTION OF THE INVENTION

Reference is now made to FIG. 1 of the drawing wherein a conventional transverse flow heat exchanger **10**, such as described in the patents to Laing, U.S. Pat. Nos. 3,347,059 and 3,424,234, is modified for use as a condensing dehumidifier in an air cycle cooling system such as described in the patent to Carson et al, U.S. Pat. No. 2,586,002. Air from the compressor, not shown, is supplied to the inlet **12** to the rotary heat exchanger element **14** which is driven by a belt **16** and motor **18**. Rotary seals, not shown, are provided between end conduits, **22** and **24**, of the rotary element **14** and the inlet and outlet conduits **25** and **26** respectively. The air passes through end channel **27** and then through vane members **29** to a second end member **31**. The air then passes through an expansion turbine, shown in block **33**, in a manner similar to that described in the U.S. Pat. No. 2,586,002. The turbine may be used to provide shaft power for auxiliary compression or may be used for other purposes such as driving electrical generators.

The cooled air from the expansion turbine is supplied to a conditioned compartment, not shown, through a conduit **35**, by means of the transverse flow heat exchanger fan **14**. As the air passes over the vanes **29**, it cools the air within the vanes to condense moisture in the air. The moisture is removed from rotary heat exchanger by providing a plurality of poppet valves **38** around the periphery of the heat exchanger end member **31**. When no water is present, in the end member, the valves **38** will remain closed. The springs of the poppet valves are set to maintain the valves closed against the air pressure within the system which would be of the order of 100 psia. When water collects in the end member, the centrifugal force on the water together with the air pressure overcomes the spring of the poppet valves to allow the water to escape through the poppet valves into nozzle members **40**. This water then passes through nozzle members **40** into an annular trough **42** and outlet **44**.

In the operation of the device, air from a compressor, not shown, is supplied at inlet **12**. The air passes through the vanes **29** to end member **31** and then out through conduits **24** and **26** to the expansion turbine **33**. The air is cooled by expansion in the expansion turbine and then passed through conduit **35** to the rotary heat exchanger and then to the compartment to be cooled. The air in conduit **35** cools the air in vanes **29** as it passes over them. The water condensed in the vanes **29** is moved by viscus interaction with the air in the vanes to end member **31** where it collects and is passed out through poppets **38** to be collected in trough **42** from which it passes to outlet **44**.

It places where leakage from trough **42** is not a problem, the device of FIGS. **1** and **2** may be used. When leakage is a problem, some means is needed to provide a seal for trough **42**. An alternative arrangement is shown in FIG. **3**.

In this device, the nozzle **40** and trough **42** are replaced by reservoirs **50**, which are sealed to end member **31**. Tubular members **52** carry the water to an annular reservoir **54** which is secured to conduit **24'**. Openings **55** are provided in the reservoir **54** so that water may pass to an annular trough **56** which is sealed to reservoir **54** by O-ring seals or other seal means. The water in trough **56** can pass out through conduit **58**.

The water is able to flow inward through conduit **52** against the centrifugal force since it will be driven by the air pressure in end member **31**. By bringing the water inward to reservoir **54**, a smaller exit trough and seals can be used.

There is thus provided a condensing dehumidifier for an air cycle cooling system which provides more efficient cooling to provide drier air which permits use of a system with increased cooling capacity.

We claim:

1. In an air cycle cooling system having an expansion turbine; a dehumidifier having a first air flow path and a second air flow path; means for supplying high pressure air to said first flow path; means for supplying air from the first flow path to said expansion turbine; whereby said air is cooled to a low temperature; means for supplying cooled air from said expansion turbine to the second flow path of said dehumidifier whereby the moisture in the air in said first flow path is condensed to form water; said dehumidifier comprising a trans-

verse flow fan having a rotary fan member and an air duct surrounding the fan member; said fan member having a plurality of hollow vanes forming the first flow path within the vanes; said air duct forming the second air flow path through the rotary fan member external to the vanes; said rotary fan member having an end member for collecting water formed by the moisture condensed in the first flow path within said vanes; means, responsive the centrifugal force on the water in said end member for removing the water from said end member.

2. The device as recited in claim **1** wherein said means for removing the water from the end member includes a plurality of poppet valves, adapted to remain close in response to said high pressure air alone and adapted to open in response to said high pressure air and the centrifugal force on the water when water collects in the end member; means, positioned adjacent the poppet valves, for carrying the water, passing through the poppet valves, away from the end member.

3. The device as recited in claim **2** wherein said means for carrying the water away, includes a nozzle, surrounding each poppet valve, secured to said end member; an annular stationary trough positioned in water receiving relation to the nozzles; a drain outlet connected to said annular trough.

* * * * *