Jan. 7, 1958 J. A. WHITE 2,819,330

HEAT TRANSFER SYSTEM

Filed Feb. 17, 1955 2 Sheets-Sheet 1

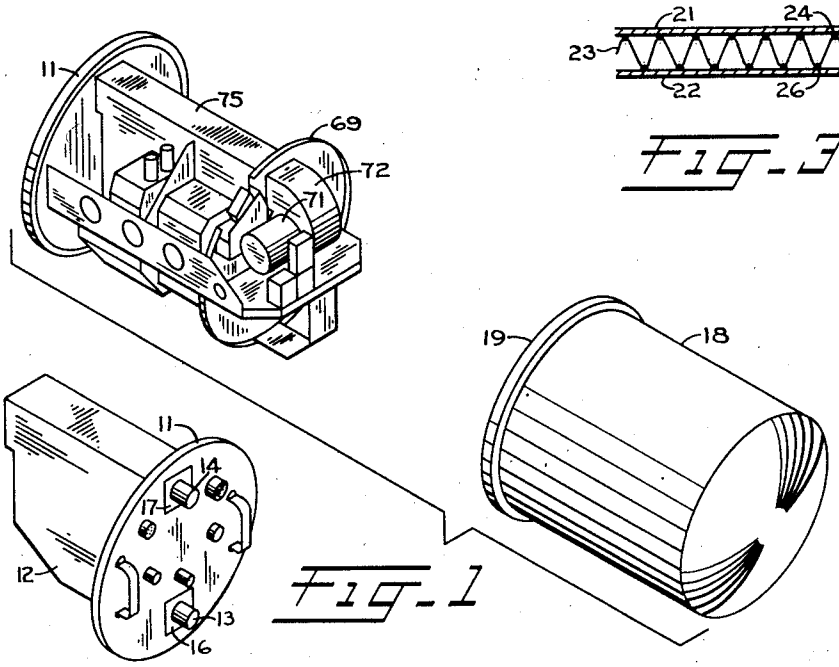


Fig. 1

Fig. 3

Fig. 2

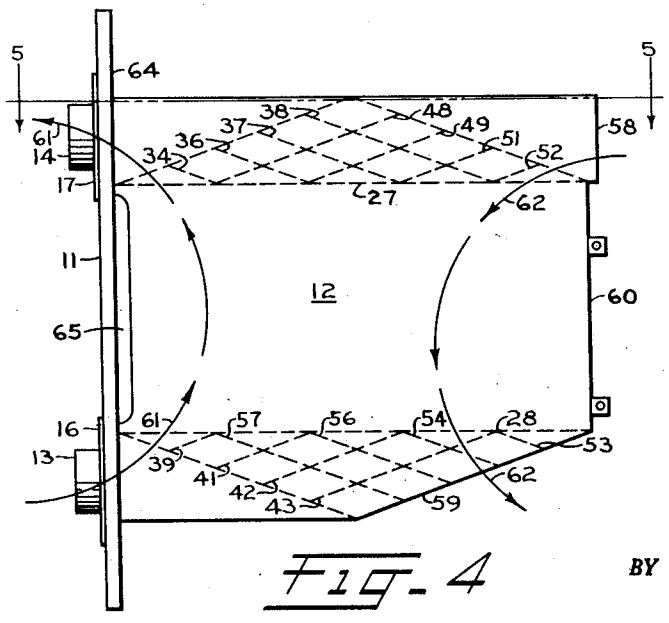


Fig. 4

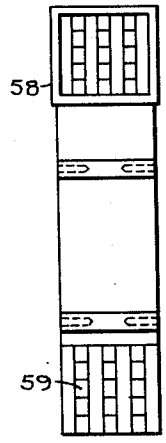


Fig. 6

INVENTOR.
JOHN A. WHITE

BY H. L. Mackey

ATTORNEY.

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HEAT TRANSFER SYSTEM

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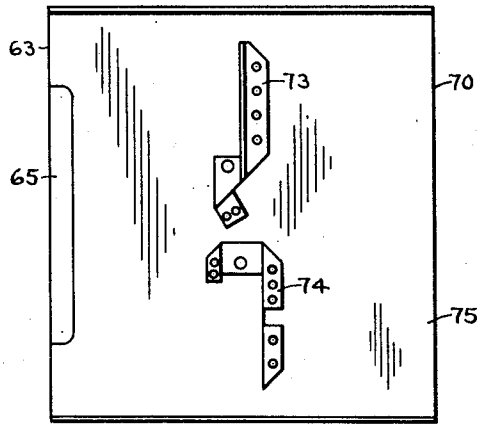


Fig. 7

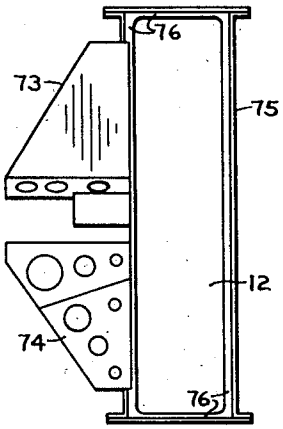


Fig. 8

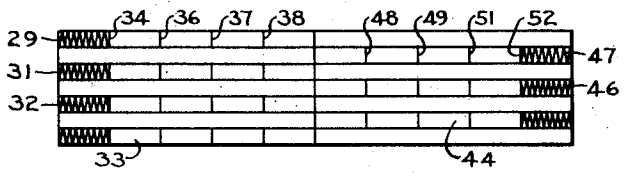


Fig. 5

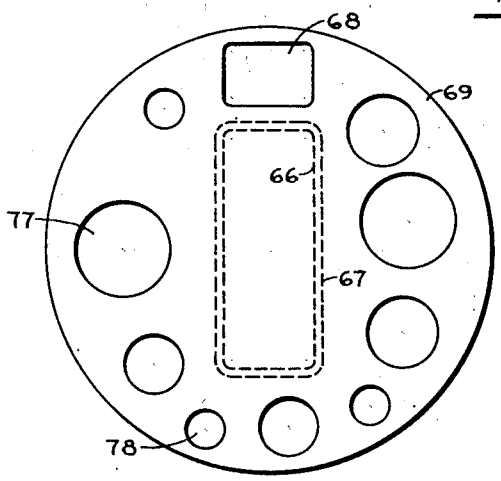


Fig. 9

INVENTOR.
JOHN A. WHITE

BY H. A. Mackay

ATTORNEY.

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HEAT TRANSFER SYSTEM

John A. White, Yonkers, N. Y., assignor to General Precision Laboratory Incorporated, a corporation of New York

Application February 17, 1955, Serial No. 488,748

2 Claims. (Cl. 174—16)

This invention relates to heat transfer systems containing heat exchangers, and particularly to such systems employed for cooling apparatus having energy losses dissipated as heat.

This invention is particularly useful in aircraft designed for high altitude operation and having pressurized spaces. When this invention is employed in such aircraft the cold rarefied air of high altitudes may be used for cooling the apparatus while permitting operation in a hermetically sealed case containing a gaseous filling at relatively high pressure. The hermetically sealed case may be in turn positioned in a space containing air which can be at any pressure and at any temperature ranging from much colder than the desired apparatus temperature to much hotter, without preventing adequate cooling of the apparatus.

An object of this invention is to provide an improved, readily assembled construction for housing apparatus, wherein the apparatus may be hermetically sealed yet readily made available for servicing when necessary.

Another object of the invention is to provide compact mounting and housing devices for electronic apparatus which may be hermetically sealed yet cooled by the introduction of a coolant fluid, wherein the circuit components are substantially shielded from external electrical interference.

Still another object of the invention is to cool apparatus by means of fluid coolant kept from contact with the apparatus and at a separate pressure, the envelope of the apparatus being surrounded by an atmosphere which may be different in temperature and pressure from those of both the coolant and the apparatus.

This invention employs a heat exchanger with two separate sets of fluid ducts. This heat exchanger also serves as a mechanical core supporting the apparatus to be cooled. The apparatus secured to this core is surrounded by a hermetically sealed case or envelope which also provides mechanical protection and may serve as an electrostatic shield. A small motor circulates fluid around the apparatus and through one set of heat exchanger ducts in a closed fluid path wholly within the hermetically sealed case. A second set of fluid ducts of the heat exchanger is connected to ingress and egress pipes which pass through the walls of the hermetically sealed case. When the invention is employed in an aircraft these pipes may be connected for circulation of cooling air through the second set of ducts, the air being taken from outside the aircraft or elsewhere.

By using this construction rarefied cold air may be used for cooling while high pressure dried air is recirculated through the apparatus. When the apparatus is electrical this is an important feature since it prevents dirty or humid air from coming in contact with the apparatus. The temperature of the air surrounding the case has negligible effect on the apparatus temperature because neither the apparatus nor the heat exchanger is in effective conductive contact with the case.

Further understanding of this invention may be secured

from the detailed description and associated drawings, in which:

Figure 1 depicts the complete assembly of an electronic instrument, with the case drawn off, employing the heat transfer system of this invention.

Figure 2 is a view of the base and heat exchanger used in connection with the invention.

Figure 3 depicts a detail of the interior of the heat exchanger.

Figure 4 is a side view of the heat exchanger.

Figure 5 is a section taken on the line 5—5 of Fig. 4.

Figure 6 is a rear view of the heat exchanger.

Figure 7 is a side view of the frame used in connection with the invention.

Figure 8 is a rear view of the frame enclosing the heat exchanger.

Figure 9 depicts the bulkhead used in connection with the invention.

Referring now to Fig. 1, a base or end plate **11** serves as the fundamental construction element of the device of the invention. To this plate the heat exchanger **12**, Fig. 2, is secured by means of its terminal pipes **13** and **14** and associated flanges **16** and **17**. The cylindrical case **18**, Fig. 1, is also secured to the base **11** by a hermetic seal at the edge **19**.

The heat exchanger **12** is made of seven thin elements, all alike and each constructed as indicated in the cross section of Fig. 3. Each element consists of two thin metal side plates **21** and **22**, with a single thin metallic sheet **23** repeatedly folded between them and welded to the side plates at each fold as at welds **24** and **26**. The element thus forms a cellular sandwich containing many tiny parallel air passages between two opposite edges. These opposite edges or sides are indicated by the dashed lines **27** and **28**, Fig. 4, depicting the top and bottom terminating surfaces of all of the cellular air passages of the seven elements. Four of the seven sandwich elements form the air path between the pipe terminals **13** and **14**. These four elements **29**, **31**, **32**, and **33**, Fig. 5, are each provided with four metallic sheet deflectors so that air passing vertically up through the cellular passages is deflected toward the exit pipe **14**. These four deflectors are indicated by the dashed lines **34**, **36**, **37** and **38**, Fig. 4, their end edges being visible in Fig. 5. Similar deflectors **39**, **41**, **42** and **43** guide air from pipe terminal **13** into the bottoms of the four elements. Three other sandwich elements **44**, **46** and **47**, are interleaved between elements **29**, **31**, **32** and **33** as indicated in Fig. 5. They are similarly provided with top and bottom deflectors **48**, **49**, **51**, **52**, **53**, **54**, **56** and **57**, Fig. 4. The upper ends of the passages of elements **44**, **46** and **47** terminate in a rectangular pipe opening **58**, Figs. 4 and 6, while the lower ends of the same passages terminate in the open rectangular area **59**, Fig. 4.

In the operation of this exchanger the counterflow principle is employed. The pipe terminal **13** serves as the input for externally-provided cooling air. This air is deflected by deflectors **39**, **41**, **42** and **43** into the lower ends of the several thousands of cellular passages in elements **29**, **31**, **32** and **33**, Fig. 5. The air passes vertically upward as indicated by arrows **61**, Fig. 4, and out pipe terminal **14**. A second completely separate set of air paths starts at the rectangular pipe opening **58**. The air is deflected by deflectors **48**, **49**, **51** and **52** into the vertical cellular passages of elements **44**, **46** and **47**, Fig. 5, and passes downward as indicated by arrows **62**, Fig. 4, until it is deflected by deflectors **53**, **54**, **56** and **57** and is exhausted out the opening **59**.

A frame **75**, Figs. 7 and 8, has the general shape of a rectangular box of four sides with open ends. Its dimensions are such as to fit around the heat exchanger **12**, Fig. 4, leaving a space of about 3/16 inch on all four sides,

as indicated in Fig. 8. The front edge **63** of the frame is designed to be secured to the inside surface **64**, Fig. 4, of the base **11**. Two cutouts **65** provide connection between the 3/16" interwall space and the surrounding space.

A bulkhead **69**, Fig. 9, has a circular perimeter fitting the inside of case **18**, Fig. 1. It is secured to the rear side **60**, Fig. 4, of the heat exchanger, indicated by dashed lines **66**, Fig. 9, and to the rear end **70**, Fig. 7 of the frame as indicated by dashed line **67**, Fig. 9. The bulkhead thus hermetically seals the space between heat exchanger and frame at the rear. A rectangular opening **68** fits around the rectangular pipe terminal **58**, Figs. 4 and 6. The bulkhead **69** is visible in Fig. 1. A motor **71** and a blower **72** are secured to bulkhead **69** and the blower outlet is connected through a hose to the rectangular opening **58**, Fig. 4, of the heat exchanger.

Numerous electronic and electrical components are secured to the frame and to the bulkhead. Some components are secured to the frame brackets **73** and **74**, Fig. 7, and others to numerous other brackets and details which have been omitted to clarify the description but which are depicted or inferred in Fig. 1. This type of construction provides accessibility and facilitates testing and subassembly replacement. All components and even the complete external cooling system may be operated with the case removed, as the case forms no part of the external cooling system and plays no part in its cooling action.

In the operation of the device of this invention let it be supposed that the apparatus is installed in a pressurized compartment of a high altitude airplane. Cooling air may be taken from outside the airplane so that when the airplane is at a high altitude the cooling air pressure will be low being, for example, at a pressure of one pound per square inch absolute at an altitude of 62,000 feet. However, it is not necessary to use external chilled air for external cooling. The warm air vented from the passenger cabin may be used for cooling even though its temperature may be as high as 131° F. Its pressure will be between 10 and 14.7 lbs. per sq. in. abs. In one design the internal hottest spot temperature was held to +185° F. when +131° F. air was used for cooling, and when the air ambient around the cover **18** had a temperature of +250° F.

The path of the external cooling air passed into the pipe terminal **13**, Fig. 4, is as shown by the arrows **61**, passing through the numerous cellular passages of the elements **29**, **31**, **32** and **33**, Fig. 5, and out pipe terminal **14** to an external exhaust point. The path of the internal cooling air is from the blower **72**, Fig. 1, through its hose connection to the rectangular pipe opening **58**, Fig. 4, through the numerous cellular openings in elements **44**, **46** and **47**, Fig. 5, as schematically indicated by arrows **62**, Fig. 4, out opening **59**, through the 3/16 inch spaces **76**, between the frame **75** and heat exchanger **12**, Fig. 8, to the front of the frame, and through the two openings **65**, Fig. 7, to the space between frame and case occupied by the electronic apparatus. The air then finds its way toward the rear through, around and over the electronic apparatus to the bulkhead, Fig. 9, and flows through the holes such as holes **77** and **78** provided therein for the purpose. The air then passes over and around apparatus fastened to the rear surface of the bulkhead and finally enters the intake of blower **72**, Fig. 1, and is recirculated.

What is claimed is:

1. A heat transfer system comprising, a base, a heat exchanger including two sets of ducts positioned in heat exchanging relationship but hermetically isolated from each other secured to said base, an apparatus frame enveloping said heat exchanger and secured thereto, electronic apparatus being capable of energy loss and of emitting loss energy as heat, said electronic apparatus containing interstices and spacers for the transmission of cooling gases, an enveloping case removably hermetically sealed to said base hermetically sealing said apparatus from the ambient atmosphere, means externally forcing cooling gas through orifices in said base into, through and out of one set of ducts in said heat exchanger, said one set of ducts being hermetically isolated from the interior of said enveloping case, an air blower secured to said apparatus frame recirculating an internal cooling gas inside said enveloping case through another set of ducts of said heat exchanger and through the interstices and spaces of said electronic apparatus.

2. A heat transfer system for electronic apparatus comprising, a heat exchanger unit including two sets of ducts positioned in heat exchanging relationship but hermetically isolated from each other, an enclosure member closely surrounding but spaced from said heat exchanger unit providing a fluid passageway between the exterior walls of said heat exchanger unit and the interior walls of said enclosure member, a base plate sealed to one end of said heat exchanger unit and said enclosure member, a blower carried by said base plate and positioned in fluid conducting relationship with the inlet of one of said sets of ducts, the outlet of said one set of ducts being in fluid communication with the fluid passageway between the walls of said heat exchanger unit and said enclosure member, fluid ports in the walls of said enclosure member at the end opposite to said base plate, means for attaching heat emissive electronic apparatus to said enclosure member, said heat exchanger unit, enclosure member, electronic apparatus, base plate and blower being contained within a casing hermetically sealed from the surrounding atmosphere, and inlet and outlet ducts in said casing communicating with the other of said set of ducts.

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