Oct. 21, 1969 KUNIO FUJIE 3,473,603

HEAT EXCHANGER

Filed Jan. 20, 1967 2 Sheets-Sheet 1

FIG. 1

Prior art

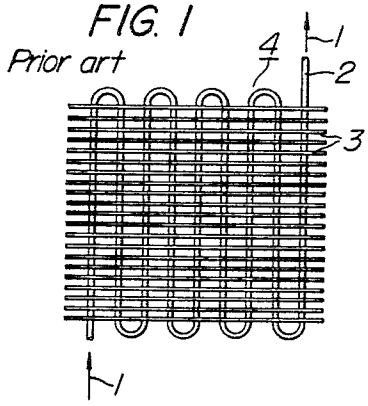


FIG. 2

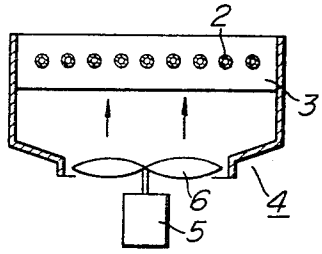
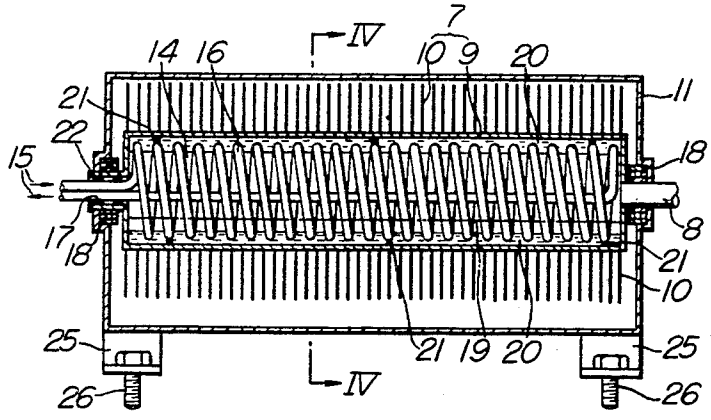


FIG. 3



INVENTOR
KUNIO FUJIE

BY Paul M. Craig, Jr.
ATTORNEY

Oct. 21, 1969 KUNIO FUJIE 3,473,603

HEAT EXCHANGER

Filed Jan. 20, 1967 2 Sheets-Sheet 2

FIG. 4

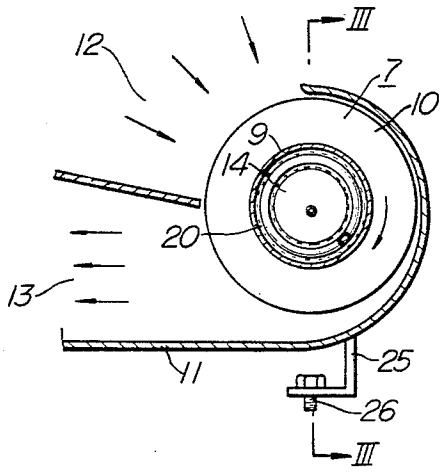


FIG. 5

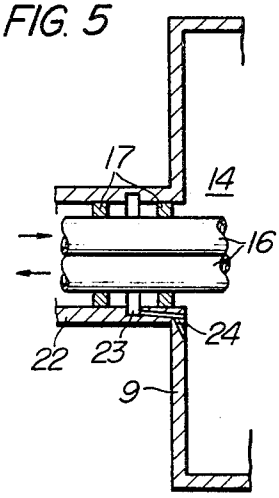


FIG. 6

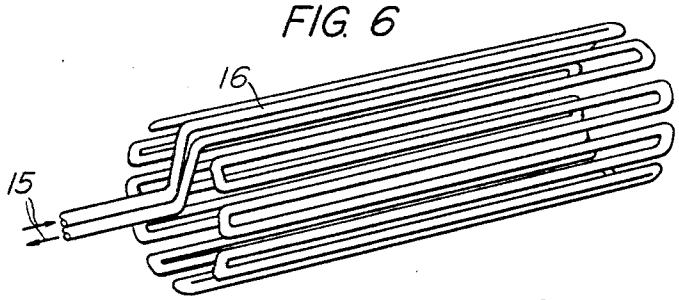
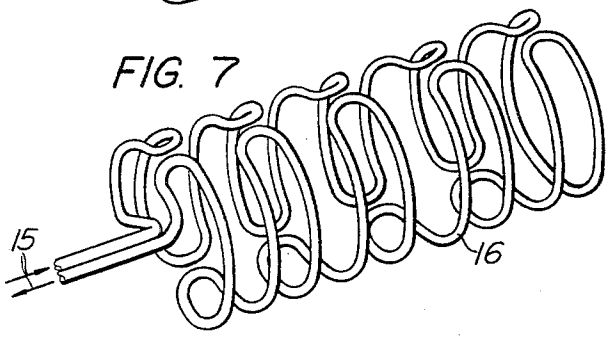


FIG. 7



INVENTOR
KUNIO FUJIE

BY Paul M. Craig, Jr.
ATTORNEY

United States Patent Office 3,473,603 Patented Oct. 21, 1969

3,473,603

HEAT EXCHANGER

Kunio Fujie, Tokyo, Japan, assignor to Hitachi, Ltd., Tokyo, Japan, a corporation of Japan

Filed Jan. 20, 1967, Ser. No. 610,647
Claims priority, application Japan, Jan. 26, 1966, 41/4,041
Int. Cl. F28f *13/12;* F24h *3/06;* F28d *11/02*
U.S. Cl. 165—122 3 Claims

ABSTRACT OF THE DISCLOSURE

A rotary heat exchanger of the type equipped with a disk friction fan having a hollow rotary shaft in which a pipe defining a path of a fluid to be subject to heat exchange is disposed in close proximity to the inner wall of the hollow space in the hollow rotary shaft so that upon rotation of the heat exchanger the pipe can be fully immersed in a liquid heat exchange medium accommodated in the hollow space in the hollow rotary shaft.

This invention relates to improvements in heat exchangers of the type having a fan integrally incorporated therein, and more particularly to a novel rotary heat exchanger having a disk friction fan integrally constructed therewith.

Various kinds of heat exchangers have heretofore been proposed and found their individual applications in the art of heat exchange. Among these heat exchangers, forced air cooling heat exchangers designed for the forced air cooling of fluids have especially been preferred and finding applications in various kinds of apparatus by virtue of their high heat transfer effectiveness. A typical conventional structure of such forced air cooling heat exchangers is schematically illustrated in FIGS. 1 and 2 in which it can be seen that the heat exchanger comprises a finned heat exchanger section 4 formed by fixing a plurality of heat radiating fins 3 to a pipe 2 which defines therein a path of a fluid 1, and a fan section 6 driven from a motor 5. In this type of heat exchanger, air is forcibly supplied from the fan section 6 toward the heat exchanger section 4 to increase the fin-side heat transfer of the pipe 2 for thereby enhancing the heat transfer effectiveness.

However the heat exchanger described above is not only costly to make due to the fact that separate provision of the heat exchanger section and the fan section results in the high cost which is the sum of the costs of these two sections, but also necessarily occupies a large overall volume due to the separate provision of these two sections. The heat exchanger of this type is therefore unsuitable for use, for example, as a domestic air conditioner or an automotive vehicle heater for which the small size is an essential demand. Further, with such structure, an attempt to increase the air velocity to thereby increase the fin-side heat transfer will result in a remarkable increase in the resistance against the air flowing between the fins, thus necessitating a larger fan power and a larger fan size and increasing the noise beyond an allowable limit. Moreover, the fan employed in the conventional heat exchanger of the type described above is either a propeller fan or centrifugal fan which has an inherent problem of high noise and a considerable technical difficulty is encountered in the successful reduction of the noise.

The present invention contemplates the provision of a forced air cooling heat exchanger of novel structure which is quite free from the defects involved in the prior art forced air cooling heat exchangers as described above and has for its primary object to provide a small-sized

and hence inexpensive heat exchanger yet having a high heat transfer effectiveness.

Another obejct of the present invention is to provide a heat exchanger operating at quite a low noise level which is especially useful for applications where a low noise is demanded.

A further object of the present invention is to provide a heat exchanger which can provide leak-free operation in cooling a fluid such as a high pressure gas.

Another object of the present invention is to provide a heat exchanger which, when for example used as an air conditioner, can suppy an air stream of large width corresponding to the desired air supply range and by which the air stream can be delivered in the form of slit-like flow as from the blow-out port of conventional air conditioners.

The heat exchanger according to the present invention is characterized by the provision of a disk friction fan or more commonly a rotary heat exchange means integrally incorporated therein, said disk friction fan or rotary heat exchange means comprising a plurality of substantially equally spaced disks fixed to a rotary shaft at substantially right angle with respect thereto for integral rotation with the rotary shaft so that the friction force between the faces of the disks rotating with the rotary shaft and air or gas existing between the disks is utilized to supply the desired cooling air or gas stream. The heat exchanger according to the invention has such a structure that the rotary shaft of the disk friction fan is made hollow in order that a pipe defining a path of a fluid to be subject to heat exchange can be disposed in the hollow space in the hollow shaft and a liquid heat exchange medium having a good heat conductivity such, for example, as turbine oil can be accommodated in the hollow space in the hollow shaft in heat exchange relation with such fluid passing through the pipe. By virtue of the above structure, the pipe through which the fluid to be subject to heat exchange passes can be fully immersed in the liquid heat exchange medium, a high rate of heat transfer can be obtained between the fluid in the pipe and air or gas forcedly supplied by the disk friction fan, and the disks themselves of the disk friction fan can also act as heat radiating fins to further enhance the effect of heat transfer between the fluid and the heat exchange medium.

Other objects, advantages and features of the present invention will become apparent from the following description with reference to the accompanying drawings, in which:

FIGS. 1 and 2 are a schematic plan view and a schematic elevational view, respectively, of the prior art forced air cooling heat exchanger described previously;

FIG. 3 is a sectional view of the heat exchanger embodying the present invention, the section being taken on the line III—III in FIG. 4;

FIG. 4 is a sectional view taken on the line IV—IV in FIG. 3;

FIG. 5 is an enlarged sectional view of a bearing portion in the heat exchanger of the invention; and

FIGS. 6 and 7 are perspective views showing some modified forms of a pipe through which a fluid to be subject to heat exchange passes.

Referring to FIGS. 3 and 4, the heat exchanger embodying the present invention includes a rotary shaft 9 which is rotated by a drive shaft 8 driven from a motor such, for example, as an electric motor (not shown). A plurality of substantially equally spaced disks 10 are fixed to the rotary shaft 9 at substantially right angles with respect thereto to form a disk wheel 7 which is journalled at opposite ends in bearings 18 and has an axial opening at one end thereof. The disk wheel 7 is

partly surrounded by a casing **11** so that, when the disk wheel **7** is rotated by the motor, friction force developed between the disk faces and air existing between the disks can cause forced flow of air from a direction **12** towards a direction **13** as shown in FIG. 4.

In accordance with the present invention, the rotary shaft **9** is made hollow to define therein a hollow space **14**, and a pipe **16** through which a fluid **15** to be subject to heat exchange passes extends from the exterior into the axial opening of the disk wheel **7** through seal rings **17** and is endless by spirally coiled in the hollow space **14** in the rotary shaft **9** to leave the disk wheel **7** from the same axial opening of the latter. The spiral pipe **16** is suitably supported at a plurality of portions in the hollow space **14** by support rings **21** of Teflon or like material, and a liquid heat exchange medium is filled up to a suitable level **19** in the hollow space **14** not exceeding the lower ends of the seal rings **17** in the stationary state of the rotary shaft **9** so that upon rotation of the disk wheel **7** the liquid is urged onto the inner face of the rotary shaft **9** as shown at **20** by the centrifugal force and the spiral pipe **16** can be sufficiently immersed in the layer of the liquid. The liquid heat exchange medium may preferably be a liquid such, for example, as turbine oil which has a low viscosity and a high heat conductivity and is in itself inactive so that it does not participate in any chemical reaction and does not corrode metals.

From the structure as described above it will be apparent that upon rotation of the disk wheel **7**, heat transfer between the fluid **15** flowing through the pipe **16** and the air forcedly flowed by the disk wheel **7** is conducted through the medium of the liquid **20**, and the disks **10** acting also as heat radiating fins further enhance the effect of the above heat transfer. As will be understood from FIG. 3, the liquid such as turbine oil is at a liquid level as shown at **19** not exceeding the lower ends of the seal rings **17** when the disk wheel **7** is at rest, while the liquid is thrown away to attach onto the inner face of the rotary shaft **9** as shown by the layer **20** due to the centrifugal force imparted thereto by the rotation of the disk wheel **7**. Thus there is no fear that the liquid in either case would leak to the outside through the seal rings **17** through which the pipe **16** extends into and out of the hollow space **14** in the rotary shaft **9**. Even if such leakage might tend to take place, any leakage can be positively prevented by means as shown in an enlarged partial view of FIG. 5. In FIG. 5 is will be seen that a groove **23** is cut through a certain depth of the inner face of the journal portion **22** of the rotary shaft **9** and a passageway **24** is provided to provide communication between the groove **23** and the hollow space **14** in the rotary shaft **9**. Therefore the liquid tending to leak from the hollow space **14** through the inner seal ring **17** flows into the groove **23** while effectively lubricating the sealing contact portion between the outer peripheral surface of the seal ring **17** and the inner peripheral surface of the journal portion **22** of the rotary shaft **9** and flows back again into the hollow space **14** through the passageway **24** by the action of centrifugal force. Thus any leakage of the liquid to the outside can never take place. A plurality of fittings **25** are provided at the bottom portion of the casing **11** in order to fixedly mount the heat exchanger on a suitable member by means such as bolts **26**.

In a heat exchanger according to the invention, a substantially cylindrical pipe in the form of a hollow cylinder extends longitudinally within the rotary shaft defining the heat exchanger, said pipe forming a continuous path for fluid to be subject to heat exchange. Thus the outside diameter of the rotor shaft becomes correspondingly large; however, such outside diameter of the rotary shaft **9** would in no way result in a reduced quantity of air or gas flow because it is the characteristic of a disk friction fan that the disk thereof has a low peripheral speed at a portion near the axis of the rotary shaft even with the rotary shaft of smaller outside diameter and the ability of moving the air or gas by the friction force is quite poor at such portion of the disk.

It will be understood that the pipe **16** forming the path of the fluid **15** may be bent in a zigzag or complex fashion as shown in FIGS. 6 and 7 instead of the spiral shape as shown in FIG. 3. In addition to those shapes shown in FIGS. 3, 6 and 7, the pipe **16** may take any shape so long as it runs adjacent to the inner wall of the hollow rotary shaft in sufficient heat exchange relation with the liquid accommodated in the hollow space in the shaft. By so arranging, the quantity of the liquid heat exchange medium can be reduced, which leads to an advantage of decreasing the thermal capacity of the heat exchange medium. It will be further understood that elimination of the casing will provide a heat exchanger structure which makes heat exchange while effecting an agitating operation.

It will be appreciated from the foregoing description that the heat exchanger according to the present invention having a disk friction fan integrally constructed therewith has the following advantages over prior art forced air cooling heat exchangers as described above:

(1) The heat exchanger can be made to a remarkably small-sized and light-weight unit. When compared with the prior art forced air cooling heat exchanger such as aforementioned type having the same heat flow rate and air flow rate, the inventive heat exchanger has a 1/3 volume, has a relatively simpler structure and is less expensive.

(2) It was ascertained that the relative velocity of air passing between the fins of the heat exchanger of the invention could be made more than about four times that of the prior art heat exchanger such as aforementioned type, under the condition that the blowing power is the same for both. It was therefore made certain that the rate of heat transfer between the fins (disks) and air in the inventive heat exchanger could be made more than about two times that of the prior art heat exchanger.

(3) Noise level is unquestionably low because the fan employed therein is a disk friction fan.

(4) A fluid to be brought into heat exchange relation with air continuously supplied by the disk friction fan is arranged to flow through the spiral pipe extending from the exterior into the rotary shaft. Therefore there is utterly no possibility of leakage of the fluid regardless of the kind of the fluid whether it is a liquid or a gas and regardless of pressure of such fluid. This means that the heat exchanger of the invention can for example be safely operated for the cooling of a high pressure refrigerant for air conditioning condensers and evaporators.

(5) Since the fan is constructed by fixing a plurality of disks on a rotary shaft and therefore it can be suitably extended in the axial direction to meet a particular requirement, the blow-out port can be made to a slit-like form conforming to the blow-out port of air conditioners or heaters. Thus the heat exchanger can be easily designed to suit the shape of air conditioners or heaters and can be reasonably accommodated in air conditioning or heating apparatus to provide compact and small-sized apparatus of the above kinds.

(6) The liquid such, for example, as water, oil, and non-freeze liquid etc. enclosed in the rotary shaft can not escape outwardly by being intercepted by the leak-proof means as described previously, and that portion of the liquid oozing out to the seal ring portion effectively lubricates the sealing contact between the seal ring and the inner peripheral face of the hollow journal portion of the rotary shaft.

(7) Gases other than air can be supplied by the disk friction fan and, if so required, it is also possible to feed a liquid by operating the disk friction fan as a pump. Thus the heat exchanger of the invention can not only be used as air conditioners or automotive vehicle heaters,

but also as heat exchangers in chemical industry, hygienic industry and various other industries.

What is claimed is:

1. A heat exchanger, comprising:

(1) disk friction fan means including a hollow rotary shaft and a plurality of substantially equally-spaced disks mounted on said hollow rotary shaft at substantially right angles to the axis thereof, said hollow rotary shaft and disks mounted thereon forming a disk wheel, and a housing surrounding at least a portion of said disk wheel, said housing serving to guide flow of fluid surrounding said heat exchanger through said disk wheel during rotation thereof,

(2) pipe means defining a path describing a hollow cylinder disposed generally longitudinally within said hollow rotary shaft for a fluid to be subjected to heat exchange, said pipe means extending from the exterior into an axial opening of said disk wheel, through at least one seal ring, in close proximity to the inner wall of said hollow rotary shaft,

(3) a liquid heat exchange medium contained in a space within said hollow rotary shaft, the level of said liquid heat exchange medium, in the stationary state of said disk friction fan means, not exceeding the lower most portion of said seal ring, whereby said pipe means is immersed, over a major portion thereof, within said liquid heat exchange medium as it is impelled outwardly against the inner wall of said hollow rotary shaft upon rotation thereof, and

(4) means for causing rotation of said hollow rotary shaft.

2. A heat exchanger according to claim 1, in which said pipe means defining a path for a fluid to be subject to heat exchange and extending along said hollow rotary shaft in close proximity to the inner wall of said rotary shaft is made to a spiral form.

3. A heat exchanger according to claim 1, in which said pipe means defining a path for a fluid to be subject to heat exchange and extending along said hollow rotary shaft in close proximity to the inner wall of said rotary shaft is made to a zigzag form.

References Cited

UNITED STATES PATENTS

3,322,931	5/1967	Laimg	165—122 X
2,271,862	2/1942	Hodgdon	165—92
2,616,669	11/1952	Olcott	165—92
2,991,979	7/1961	Lincoln	165—90
3,009,683	11/1961	Grieselhuber	165—92
3,022,046	2/1962	Breig	165—90

ROBERT A. O'LEARY, Primary Examiner

T. W. STREULE, Assistant Examiner

U.S. Cl. X.R.

165—90