

June 3, 1969

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3,447,603

MEANS FOR RESILIENTLY MOUNTING TUBULAR MEMBERS

Filed July 3, 1967

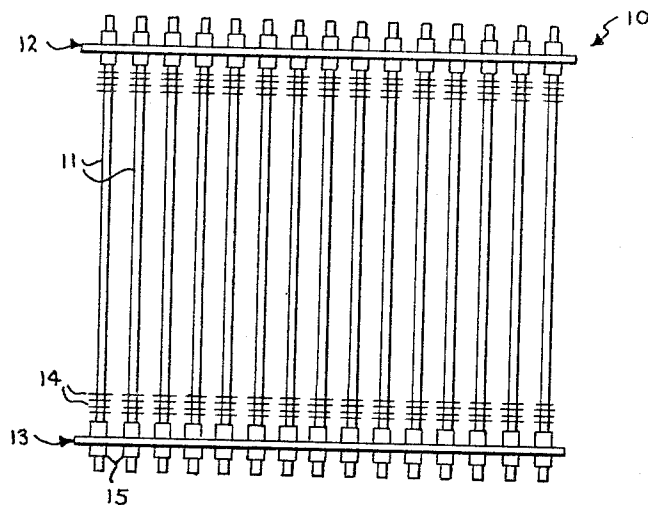


FIG. 1

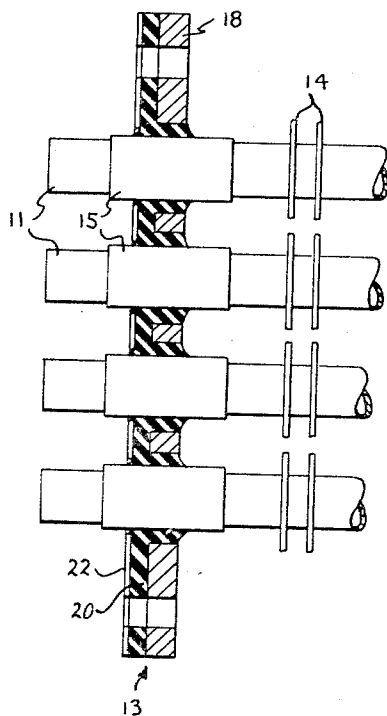


FIG. 2

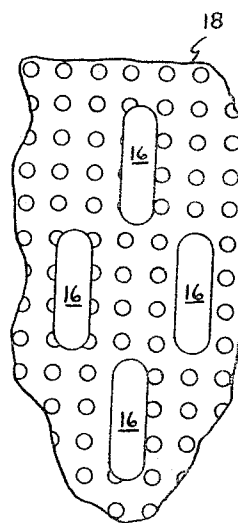


FIG. 3

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3,447,603

MEANS FOR RESILIENTLY MOUNTING TUBULAR MEMBERS

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Filed July 3, 1967, Ser. No. 651,040

Int. Cl. F28f 9/04; F16l 39/04, 27/00

U.S. Cl. 165-178

10 Claims

ABSTRACT OF THE DISCLOSURE

A tube sheet for a heat exchange device wherein sleeves are resiliently mounted within a plurality of larger openings provided in a perforated metal sheet with an elastomeric material. The surface of the elastomeric material opposite the perforated member is rendered vapor-imperious by application thereto of a layer of a suitable vapor-imperious material.

This invention relates to means for mounting tubular members and more particularly to a new and improved means for mounting the ends thereof to allow some freedom of movement of individual members relative to each other. While the following disclosure particularly relates the invention to heat exchange devices (i.e., radiators) for internal combustion engine cooling systems, it will be obvious that the invention is not thus limited, and may for example, be employed on other types of apparatus or one heat exchange devices for other types of systems without departing from the spirit or scope thereof.

Heat exchange devices are frequently made up of a plurality of parallel radiating, or heat exchange, tubes extending between, and rigidly secured to, a pair of headers, more commonly referred to in the art as tube sheets. Often these tube sheets can be made thin so as to flex slightly with changes in length of the radiating tubes due to the alternate expansion and contraction thereof under varying operating temperatures, to avoid damage to the tubes or other portions of the heat exchange device.

When a large temperature difference between adjacent tubes of the heat exchange device occurs, however, very large stresses arise between the tubes and the tube sheets. These stresses are often of sufficient magnitude to rupture the tube or tube sheet or weaken or break the joints between the tubes and the tube sheets.

For example, in the cooling system described in United States Patent No. 3,067,817, the tubes of the radiator are subjected to such very large variations in temperature that the usual constructions have not been satisfactory. In that system, there is either a large stream of coolant flowing from the engine to the radiator or none at all. That is, there is either no coolant in the radiator, and the tubes, without coolant therein, are subjected to the surrounding outside ambient temperature, which may be as low as about -60° F., or the radiator is subjected to a large flow of coolant which may be at a temperature as high as about 185-200° F. Moreover, this hot coolant does not instantaneously reach all radiating tubes or all portions thereof at the same time so that individual radiating tubes are subjected to widely varying temperatures and temperature gradients. For example, some of the radiating tubes may be rapidly increasing in length due to the presence of the hot coolant while other tubes, having no coolant therein, are not changing in length.

Prior art attempts to solve this problem have not been satisfactory. For example, it has been proposed in the prior art British Patent 741,625 to provide tube sheets with a series of openings each of which included a flange and a cap therefor and into which openings a resilient hollow plug or grommet was inserted. The ends of the

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radiating tubes were then inserted into the hollow plugs or grommets to provide a resilient connection between the radiating tube and the tube sheets. Although such a mounting means allows for increases and decreases in length of the radiating tubes by allowing for sliding movement of the tubes through the grommet, such a construction has not been entirely satisfactory. For example, although a satisfactory mechanical connection can be achieved between the grommet, the tube, and the tube sheet, the liquid seal between the grommet and the tube has not been entirely satisfactory.

It has also been proposed to employ tube sheets of a rubber composition. For example, one such arrangement was disclosed in United States Patent No. 2,240,537, Young, wherein a plurality of sleeves are vulcanized into a tube sheet of a rubber composition; the sleeves having openings therein which are adapted to receive the ends of the radiator tubes. Because the entire tube sheet is made of resilient material (rubber) the radiator tubes are free to expand and contract individually and any tube vibrations pass into the rubber tube sheet and are absorbed thereby. Although such an arrangement provided for a satisfactory liquid tight seal which accommodated individual tube movement, the sheet itself was not mechanically strong enough to prevent sagging so that in any radiator of large size some additional reinforcing means was required. Also, the usual distortion, shrinkage and the like which took place when the rubber tube sheet was cured so varied the pattern of the sleeves that assembly of the radiator tubes into such sleeves was not only extremely difficult, but sometimes impossible.

It has been discovered that the foregoing manufacturing and operating difficulties could be obviated by employing a construction employing a rigid tube sheet having openings punched, or otherwise provided therein, in a desired pattern into which openings the sleeves were suitably resiliently secured as by an elastomeric material suitably bonded to the tube sheet and the sleeve. This allowed the pattern to be maintained during curing so that the heat exchanger tubes could be readily installed in the sleeves and also provided a mechanically rigid, self-supporting tube sheet which allowed for individual movement of the tubes secured thereto. In spite of this, the foregoing structure still failed to provide a heat exchange device which had an entirely satisfactory operating lifetime, and this was most especially so in severe operating environments such as that to which the radiator for a locomotive cooling system of the type described in the United States Patent No. 3,067,817 would be subjected. For example, under actual operating conditions, liquid-filled blisters were found to form in the elastomeric material and, since rupture of such blisters could result in a leak, this condition may result in premature failure of the radiator.

It is an object of this invention, therefore, to provide a new and improved tube sheet arrangement for heat exchange devices which substantially overcomes one or more of the prior art difficulties and exhibits increased operating lifetime.

It is another object of this invention to provide a new and improved tube sheet arrangement for heat exchange devices which exhibits mechanical rigidity while at the same time, allowing for individual movement of the tubular members mounted thereto, exhibits long operating lifetime, reduced maintenance and which does not require complex and expensive manufacturing procedures.

In its broader aspects, the present invention provides for a new and improved tube sheet arrangement of the type wherein sleeves are resiliently mounted within openings in a rigid reinforcing member and wherein the surface of the elastomeric material exposed to the heated

fluid of the system is smaller than the surface area exposed to the ambient temperature.

Briefly stated, in accordance with one aspect of this invention, a new and improved tube sheet for a heat exchange device comprises a perforated member of metal or other suitable material exhibiting the required amount of structural integrity to provide a heat exchanger tube sheet. The perforated member is provided with a plurality of larger openings therein arranged in a preselected pattern so that one opening is provided for each of the radiating tubes of the heat exchange device. A plurality of sleeves are also provided one of which is positioned within each of the openings and resiliently secured therein by an elastomeric material which is intimately and irreversibly bonded to the sleeves and to the perforated member. The sleeves have an outside dimension smaller than the openings in the perforated member and are adapted to embrace an end of a radiating tube and be suitably secured thereto so that the radiating tubes are thus arranged to be resiliently mounted to the perforated member. The surface of the elastomeric material remote from the perforated member is rendered vapor-impervious in any suitable manner such as by bonding thereto at least one layer of a suitable vapor-impervious material, such as metal, a fluorocarbon material or the like or the group consisting of polytetrafluoroethylene, polytrifluorochloroethylene, combinations thereof and materials treated therewith.

The novel features believed characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, together with its organization and method of operation will best be understood by reference to the following description taken in conjunction with the accompanying drawing in which:

FIG. 1 is a perspective view of a heat exchange device incorporating this invention with the inlet and outlet tanks and ductwork removed;

FIG. 2 is a partial sectional view of one embodiment of the tube sheet construction of this invention; and

FIG. 3 is a top view of the perforated member showing the small openings of the member and the larger openings provided therein in the desired pattern.

In FIG. 1 there is shown a portion of a heat exchange device with inlet and outlet tanks and all external ductwork removed. The portion of the heat exchange device is generally designated 10 and comprises a plurality of heat exchange, or radiating, tubes 11 extending between two tube sheets 12 and 13. The tube sheets 12 and 13 are adapted to connect to inlet and outlet tanks respectively, so that one fluid, such as water for example, may be circulated through the tubes and a second fluid, such as air, may be circulated externally of the tubes. In order to increase the heat exchange between the fluids, the radiating tubes are generally provided with external fins 14.

In accordance with this invention, means are provided for resiliently mounting the radiating tubes between the inlet and outlet tanks to allow for individual changes in their lengths under varying temperature conditions while maintaining a perfect and positive liquid seal at all times. To this end, I have provided means for rigidly securing the ends of the radiating tubes to a short metal sleeve, or ferrule, which ferrule has been resiliently mounted by bonding it intimately to a region of an elastomeric material. The details of the tube sheet in accordance with one embodiment of this invention are shown more clearly in the enlarged portion of tube sheet 13 illustrated in FIG. 2.

Preferably, the novel tube sheet arrangement of this invention is employed at both ends of the radiating tubes although for many applications, satisfactory results may be achieved by providing such tube sheet at only one end.

As shown in FIG. 2, the tube sheet arrangement of this invention includes a number of sleeves, or ferrules, 15 which are intimately and irreversibly bonded within the larger openings 16 punched, or otherwise suitably pro-

vided, in a preselected pattern in a perforated member 18 by an elastomeric material 20. The relation between the openings making up the perforated member 18 and the larger openings 16 is shown more clearly in FIG. 3. The ends of the radiating tubes extend through the sleeves 15 and are rigidly secured thereto, such as by soldering, brazing, welding, expanding or any other suitable means of providing a rigid, leakproof connection. In accordance with this invention, at least the major portion of the surface of the elastomeric material 20 opposite the perforated member 18, and preferably the entire portion of such surface, is rendered vapor-impervious. Conveniently, this may be provided by applying to such surface a layer 22 of a suitable vapor-impervious material such as a metal, a fluorocarbon polymer or other suitable material. Although the precise nature of the liquid-filled blister formation in the elastomeric material in the prior construction is not as yet fully understood, it is believed to be due to moisture vapor absorbed by the elastomeric material which vapor then condenses as it nears the cool surface of the rigid reinforcing plate.

In accordance with this invention, therefore, a tube sheet arrangement is provided wherein the surface area of the elastomeric material exposed to the hot fluid is smaller than the surface area exposed to the outside ambient temperature. This is accomplished in one embodiment by providing the reinforcing member with many small perforations and applying a vapor-impervious layer to the surface of the elastomeric material.

The layer 22 should be capable of withstanding the extremes of temperature to which the tube sheet is subjected during operation as well as during its manufacture. For example, if the radiating tubes 11 are to be secured into the sleeves 15 by means of a roller expanding operation, the outer layer 22 of vapor-impervious material need only be required to withstand the extreme operating temperatures. On the other hand, if the tube ends are to be secured into the sleeves 15 by a soldering operation, such as a dip soldering technique for example, the outer layer 22 (and the elastomeric material itself) must be capable of withstanding the soldering temperature (e.g., 550° F.) for the time necessary to make the connection.

The large openings 16 in the perforated member 18 are made larger than the outside dimension of the sleeve 15 and are arranged in a pattern approximately the same as that desired for the radiating tubes to be mounted. In this way, the tube sheet, with sleeves 15 resiliently mounted within the large openings 16, may easily fit about the ends of the tubes which are thereafter rigidly secured to the sleeves. For example, the perforated member 18 may be disposed in one section of a suitable mold with the sleeves 15 positioned within the large openings 16. The elastomeric material is then introduced under suitable heat and pressure to provide the required intimately bonded resilient connection between the sleeves 15 and the perforated member 18. Also, the elastomeric material may be extended over the entire perforated member 18 as shown so as to serve as a suitable gasket between the tube sheet and the tank to which it is to be connected. The vapor-impervious layer 22, which for example, may be a thin sheet of etched Teflon having openings suitably provided therein to fit about the sleeves 15, may be bonded to the surface of the elastomeric material 20 during the foregoing molding operation. Alternatively, the elastomeric material may be molded initially to provide for the resilient bonding of the sleeves to the perforated member and the thin sheet of vapor-impervious material thereafter bonded to the surface. For example, the tube sheet may be initially molded and the mold thereafter opened and a thin sheet of a vapor-impervious material, such as etched Teflon, having openings suitably provided for therein to fit about the sleeves 15, placed on the surface of the elastomeric material. The mold is then closed again and the vapor-impervious material bonded to the surface of the elastomeric mate-

rial. In accomplishing the foregoing, it is convenient to employ an elastomeric material which exhibits self-bonding properties.

In still another alternative, a metal foil may be similarly bonded to the surface of the elastomeric material. Since the sleeves 15 are capable of readily punching the required openings in the metal foil, it is not necessary to use a metal foil sheet with openings previously provided therein.

In the foregoing described tube sheet structure of this invention, therefore, the sleeves 15 may be resiliently mounted within the large openings in the perforated member such as by molding the elastomeric material to the sleeves under suitable heat and pressure, and heat curing if required, in accordance with standard molding and bonding procedures not requiring complex or expensive tooling. Also, either at the same time or during a subsequent procedure, the vapor-impervious layer 22 may be applied. The ends of the radiating tubes are then rigidly secured to the sleeves in any suitable manner. In this respect, for example, it is only necessary that some means be provided for effecting a rigid, leakproof connection between the radiating tube and the sleeves 15 and any suitable means for accomplishing this may be employed. Conveniently, the end of the respective radiating tubes may extend into or through the sleeves and the rigid leakproof connection made in a manner which may be the same as that used in the past in rigidly securing the ends of the radiating tubes to the conventional metal tube sheet. Alternatively, a suitable butt-type connection may be made between the end of the tube and the sleeve. Thus, a rigid, leakproof connection is provided between the end of the tube and the sleeve and a resilient, leakproof, intimately bonded connection is provided between the sleeve and the region of the elastomeric material which connects the sleeve to the perforated member.

Any elastomeric material which effects an intimate bond to metal, either with or without the use of a primer or other bonding agent and which is capable of resisting the fluid employed in the heat exchange system is suitable for use in this invention. Among some of the suitable preferred materials for use in this invention, for example, are silicone rubber, natural rubber and synthetic rubber, such as polychloroprene rubber, butyl rubber and ethylene-propylene copolymer rubber. One elastomeric material which provided especially satisfactory results was compounded from a silicone rubber gum sold by the General Electric Company, Silicone Products Department, under the designation No. CE-407. Such material is self-bonding and provides a very strong intimate, and irreversible bond to the metal sleeves and the material of the perforated member 18, which bond is not affected by the coolant at the temperatures encountered, for example, in locomotive engine cooling system shown and described in United States Patent No. 3,067,817.

While only certain particular embodiments of the invention have been described in detail herein, it will be apparent to those skilled in the art that many changes and modifications may be made without departing from the invention in its broader aspects. It is intended, therefore, in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. In a heat exchange device of the type comprising a plurality of radiating tubes extending from and secured to at least one tube sheet so as to define a cooling region and wherein the side of said tube sheet remote from said cooling region is exposed to the heated fluid of the heat exchange system; a tube sheet comprising:

- (a) a plurality of sleeves adapted for rigid connection to said radiating tubes;
- (b) a reinforcing member having a plurality of openings;
- (c) an elastomeric material intimately and irreversibly bonded to said sleeves and to the one side of said reinforcing member which is exposed to the heated fluid of the heat exchange system;
- (d) said sleeves having an outside diameter smaller than that of said openings and being resiliently mounted within the openings at said reinforcing member by said elastomeric material; and
- (e) means for providing that the major portion of the surface area of the elastomeric material directly exposed to the heated fluid of the heat exchange system is rendered vapor impervious.

2. The tube sheet of claim 1 wherein said reinforcing member is a perforated member having large openings provided therein for said sleeves and the surface of said elastomeric material is rendered vapor-impervious.

3. The tube sheet of claim 2 wherein the surface of said elastomeric material is rendered vapor-impervious by a layer of vapor-impervious material in intimate association therewith.

4. The tube sheet of claim 3 wherein said layer of vapor-impervious material is metal.

5. The tube sheet of claim 3 wherein said layer of vapor-impervious material is a fluorocarbon polymer.

6. The tube sheet of claim 3 wherein said layer of vapor-impervious material is a material selected from the group consisting of polytetrafluoroethylene, polytrifluorochloroethylene, combinations thereof and materials treated therewith.

7. The tube sheet of claim 1 wherein said reinforcing member is a perforated metal plate having large openings provided therein and a layer of metal is intimately and irreversibly bonded to the surface of the elastomeric material.

8. The tube sheet of claim 1 wherein said elastomeric material is a self-bonding silicone rubber compound.

9. The tube sheet of claim 8 wherein said reinforcing member is a perforated member having larger openings provided therein to receive said sleeves and a layer of metal is bonded to the surface of said silicone rubber compound.

10. The tube sheet of claim 8 wherein said reinforcing member is a perforated member having larger openings provided therein to receive said sleeves and there is bonded to the surface of said silicone rubber compound a layer of vapor-impervious material selected from the group consisting of polytetrafluoroethylene, polytrifluorochloroethylene, combinations thereof and materials treated therewith.

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U.S. Cl. X.R.

165—69; 285—158