June 29, 1965 F. M. YOUNG 3,191,673

SECTIONALIZED HEAT-EXCHANGER CORE-UNIT

Filed April 25, 1962

FIG. 1

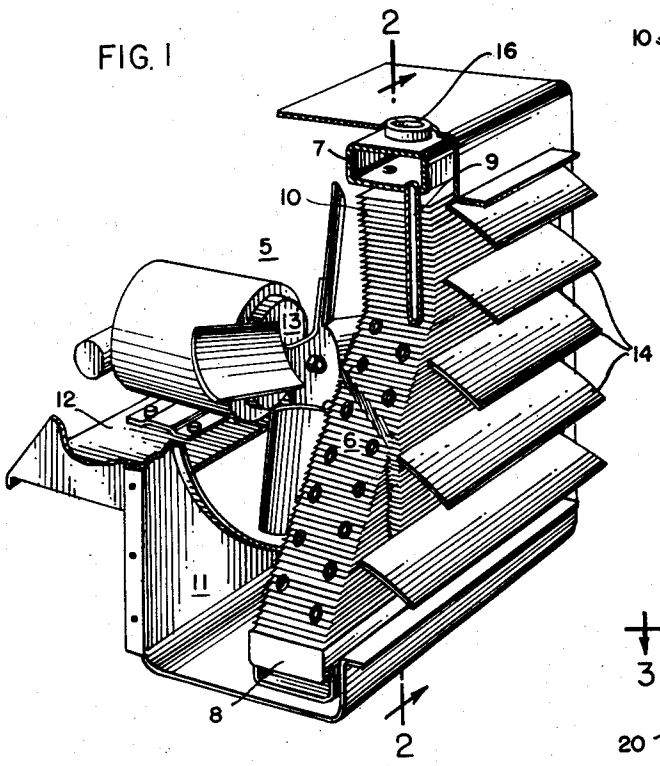


FIG. 2

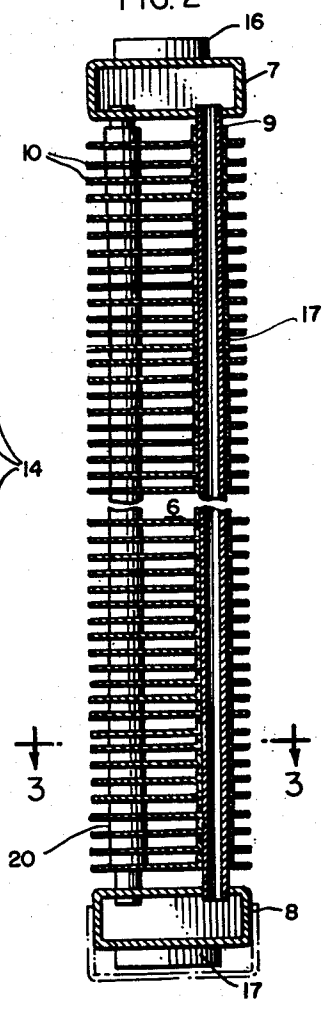
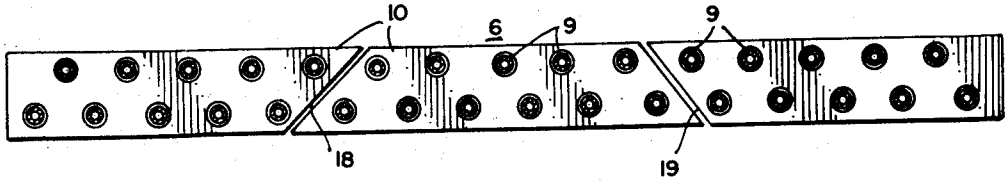


FIG. 3



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SECTIONALIZED HEAT-EXCHANGER CORE-UNIT

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This invention relates to steam-fed heat-exchangers the parts of which are formed of metals having materially different heat-expanison coefficients.

In the construction of heat exchangers, of the herein shown type, the core unit is made of a battery of parallel, closely-spaced tubes, mounting closely-spaced thin metal fins, and spanning and supporting spaced hollow headers, usually one piece. The holes in the fins are formed with perimetrical collars into which the tubes are mechanically expanded. The collars on one fin abut the adjacent fin which results in the formation of a double-wall of continuous metal for heat transfer. The tubes are bonded at the ends to the headers by scientifically-timed electrical induction.

Obtaining the best possible heat transfer for such heat exchangers requires the tubes and fins to be made from non-ferrous metal whereas the overall rigidity of the heat-exchanger requires the headers to be made from ferrous metal. Over the years the best non-ferrous metal for the tubes has been found to be copper, copper alloys, brass and/or a brass-like metal known as Admiralty. More recently the fins have been made of aluminum.

When this type of heat-exchanger is used with steam, the thermal-expanison differential of these non-ferrous and ferrous metals makes, for the manufacturer, the problem of so structuring the units as to prevent rupturing of the tubes and/or the bonds between the tubes and the headers. Also, there has been the problem of the warping or crawling of the fins along the tubes. A Standard Hand Book indicates that under temperature changes from 70° F. to 600° F. steel expands 7.2×10^6 inches per inch per degree Fahrenheit, copper expands 10.1×10^6 inches per inch per degree Fahrenheit, Admiralty metal expands 11.2×10^6 inches per inch degree Fahrenheit, and aluminum expands 14.2×10^6 inches per inch per degree Fahrenheit.

This problem of ruptured tubes and/or bonds and the distortion or displacement of the fins results from the fact that in this type of heat exchanger there is a constant "on and off" operation under thermostatic control determined by the temperature demands of the space that is being heated by these units.

Depending upon the weather conditions, these "on and off" periods may vary in frequency from 0 to 20 a day. Moreover, with steam pressures ranging from 0 to 150 p.s.i. there is a consequent temperature change in the heat-exchanger ranging from 70° F. to 366° F.

Recent carefully-controlled tests, with heat-exchangers of this type, i.e., steel headers, copper or copper-alloy tubes and aluminum fins, have shown that the ruptures of the tubes or the bonds, almost without exception, occur with the outside tubes at the ends of the headers, always at or near the tube-header joint, and, as a rule, on the wall of the tube nearest the center of the unit.

It has long been known that the incident of such ruptures could be materially reduced, if not eliminated, by making these non-ferrous metal tubes of a heavier gage material than that which the economy of manufacture and the efficiency of heat transfer respectively demand. It also has been known that aluminum fins reduce the costs of production and increase the heat-transfer efficiency. However, the expansion differential between the ferrous headers and the fins made of aluminum have

created an additional problem of having the fins become warped and crawl along the tubes where the heat-exchangers have been used with steam heat.

The main objects of this invention, therefore, are to provide an improved structuring of the core unit for high-temperature heat-exchangers to permit the formation of the tubes and fins of non-ferrous metals having the highest heat-transfer capacity consistent with the requisite tensile strength; to provide an improved heat-exchanger core-unit of this kind made in multiple sections with the tubes of all sections bonded to the opposed supporting headers; and to provide an improved heat-exchanger of this construction permitting the core-unit tubes and fins to be formed of non-ferrous metals of differing expansion coefficients having the highest heat-transfer capacity with an inherent tensile strength requisite to make the heat-exchanger as durable as those heretofore obtained with more expensive materials and having less heat transfer capacity.

In the adaptation shown in the accompanying drawings;

FIG. 1 is a perspective view of a conventional-type heat-exchanger with portions thereof broken away to more clearly show the over-all construction and assembly of the core unit and the headers and the position of the air-flow accessories;

FIG. 2 is a vertical sectional view of the same taken on the plane of the line 2—2 of FIG. 1; and

FIG. 3 is a horizontal sectional view of the same taken on the plane of the line 3—3 of FIG. 2.

The essential concept of this invention involves forming the finned-tube core in multiple sections to permit structuring the fins and headers from metals of differing expansion coefficients and highest heat-transfer capacity consistent with a tensile strength sufficient for lasting durability of the heat-exchanger over an optimum life use.

A heat-exchanger **5**, of the particular type herein shown, incorporates a core unit **6** which, embodying the foregoing concept, comprises a pair of headers **7** and **8** spanned by and supported on a battery of tubes **9** multiple groups of which mount portions of a transverse series of closely-spaced parallel fins **10**. As can be clearly seen from FIG. 3, the tubes **9** are located in staggered rows.

The heat-exchanger **5**, as herein shown, in the industry is referred to as a "unit heater." It is connected to a steam supply line most often in an over-head location for heating large open spaces, such as factories.

For such a heat-exchanger **5** the core-unit **6** is mounted on a shroud **11** having a shelf **12** for the support of a motor-driven fan **13** and the arrangement of adjustable louvres **14**. The headers **7** and **8** are formed with steam supply and return tappings **16** and **17** (FIG. 2). Such unit-heaters generally are guaranteed for use with 150 p.s.i. saturated steam. In normal operation, however, the heat exchanger **5** operates with steam pressure between 2 and 50 p.s.i. and steam temperatures of between 219° F. and 298° F., with air entering at around 65° F. and discharged at up to 298° F.

As heretofore noted, it has been the practice over the years to structure these core-units **6** with cast steel headers **7** and **8** and with the tubes **9** and the fins **10** formed of non-ferrous metal. All too often, in the past, manufacturers of such unit heaters have had too many develop leaks after a very short period of normal use. As a rule these leaks occur at the header joint of the extreme side tubes. For the manufacturer who has formed the fins of aluminum there has been the added problem of the top and/or bottom series of fins **10** warping and/or crawling into irregular-spaced position on the tubes **9**.

After a long series of tests with continuing failures in various modifications designed to remedy these twin problems of tube-joint rupture and/or fin distortion, a final

series of experiments were made with core-units 6 sectionalized as best shown in FIG. 3. With the headers cast steel, the tubes of brass of minimal wall thickness, and fins of aluminum, tests showed no leaks and less fin distortion after the equivalent of 38 years of normal use.

The core-unit 6, herein shown, is just such a unit. The headers 7 and 8 are cast steel with brass tubes 9 brazed to the headers 7 and 8 by scientifically-timed electrical induction and the tubes 9 mechanically expanded in the fin collars 20 of the aluminum fins 10, all of which is illustrated most clearly in FIG. 2.

As shown in FIG. 3, the core-unit 6 is divided into three sections by pairs of cuts 18 and 19 formed vertically of the core unit between tubes 9 at points approximately one-third the width of the core-unit 6. Although these three core sections might be fabricated separately and subsequently bonded to the headers 7 and 8, the present practice is to assemble the tubes 9 and fins 10 as heretofore they have been assembled for the conventional unit heater. After bonding the tube ends to the headers 7 and 8 in the conventional manner, a saw is used to sever the stack of fins 10 as shown by the cuts 18 and 19. The cuts 18 and 19 leave the ends of the severed fins inclined between the tubes.

A plurality of heat-exchangers 5, having their core units 6 structured in the above-described manner are branched off from a steam supply line. A conventional thermostat is connected to control each unit heater to prevent overheating or underheating and keep fuel costs to a minimum.

The aforesaid series of tests have led to theories to account for the operational causes for ruptured joints of the side tubes 9 to the headers 7 and 8, when the core units were not sectionalized, and for the absence of ruptures with the sectionalized core units, as herein shown.

The relatively lower expansion coefficient of the steel headers 7 and 8, plus their wall thickness and their opposed arrangement, establishes a condition of considerable stability bordering on rigidity as compared to the interposed finned tubes. Hence the headers, when heated, have a tendency to resist the faster-expanding thin-wall tubes 9 and the thin-fins 10. The result must be that the tubes 9 will buckle. Concurrently, the fins 10 tend to expand lengthwise thereof, radially of the tubes 9. Obviously, such expanding fins 10 tend to create radial pressures on the tubes 9 supplementing their tendency to buckle. Undoubtedly, this radial pressure against the tubes tends to increase outwardly along the longitudinally-expanding fins 10. This accumulating pressure of tube buckling and fin expansion, it is believed, results in such a strain on the extreme side tubes 9, at the opposite ends of the headers 7 and 8, as to cause the rupturing of the tube bonds to the headers, as hereinbefore explained.

In sectionalizing the fins 10, by the cuts 18 and 19, it is believed the above-mentioned transverse expansion strains from the middle section of the core unit are not communicated to the opposite end sections of the core-unit 6.

Rather, it seems reasonable to assume that in a core-unit 6, structured as herein shown and explained, the transverse expansion strains, limited to two outer sections of the core 6, have been so materially reduced as to preclude pressures of the magnitude that have heretofore occurred with the non-sectionalized core unit. For that reason, therefore, a sectionalized core-unit, as herein shown and described, is free of the incident of ruptured joints of the side tubes 9 and the respective headers 7 and 8. Moreover, such sectionalizing of the fins reduces the tendency of their buckling and/or crawling, as has been the case with the non-sectionalized unit.

Variations and modifications in the details or structure of arrangement of the parts may be resorted to within the spirit of the appended claims.

I claim:

1. A heat-exchanger core-unit, for use in a steam-heating system which is subject to constantly fluctuating pressures and temperatures, comprising:

(a) a pair of headers, each of one piece, elongated, having a single chamber of rectangular cross-section,

(b) a battery of tubes in multiple staggered rows bonded at their ends to the respective headers and disposing the headers in vertically-spaced relationship with fluid flow in one direction between the two headers, and

(c) a vertical series of transverse fins divided into multiple vertical groups approximately of the same length radially of the tubes, and embracing approximately the same number of tubes with the opposedly-spaced ends of the groups of fins disposed in common vertical planes extending throughout the entire distance between the headers and with said ends being inclined between the staggered tubes and sufficiently spaced to avoid buckling of said fins.

2. A heat-exchanger as set forth in claim 1 wherein the materials for the headers, the tubes and the fins are respectively of different expansion coefficients and tensile strengths.

3. A heat-exchanger core-unit as set forth in claim 1 wherein the headers are formed of a ferrous metal and the tubes and fins are formed of non-ferrous metal.

4. A heat-exchanger as set forth in claim 1 wherein the headers are formed of steel, the tubes are formed of copper or copper alloy, and the fins are formed of aluminum.

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