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Zoschak

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[54] HEAT FLUX SENSING DEVICE

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[52] **U.S. Cl.** .....**73/190 H,** 165/11

[51] **Int. Cl.** **G01k 17/00**

[58] **Field of Search** .....73/15, 190, 340 HF, 341; 122/392; 165/11

[56] **References Cited**

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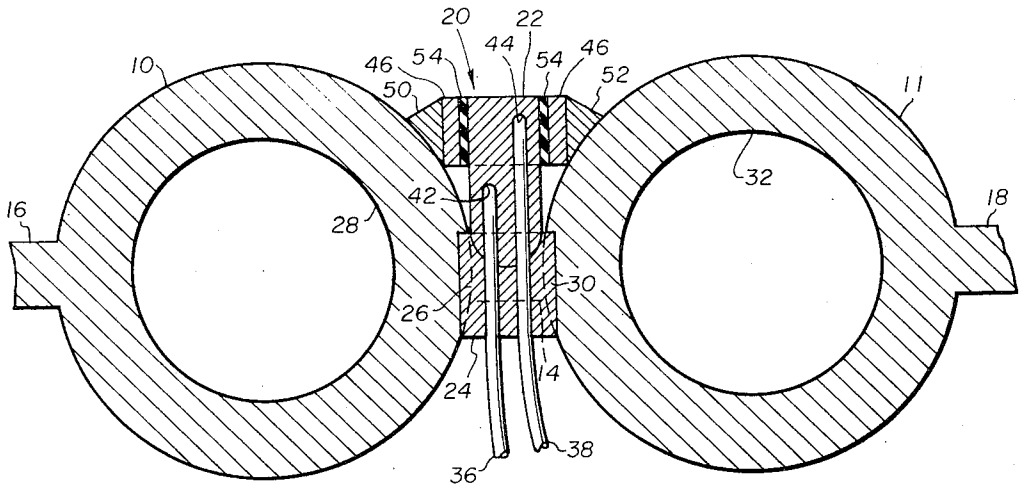
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[57] **ABSTRACT**

Heat absorption rates of cooling tubes are measured accurately without the use of devices which cause high stresses. An elongated conductor extends from between the tubes toward a heat zone on one side of the tubes and is provided with two thermocouples which have junctions at different locations along the length of the conductor, to sense a temperature gradient from which the heat flux through the conductor can be determined.

3 Claims, 3 Drawing Figures



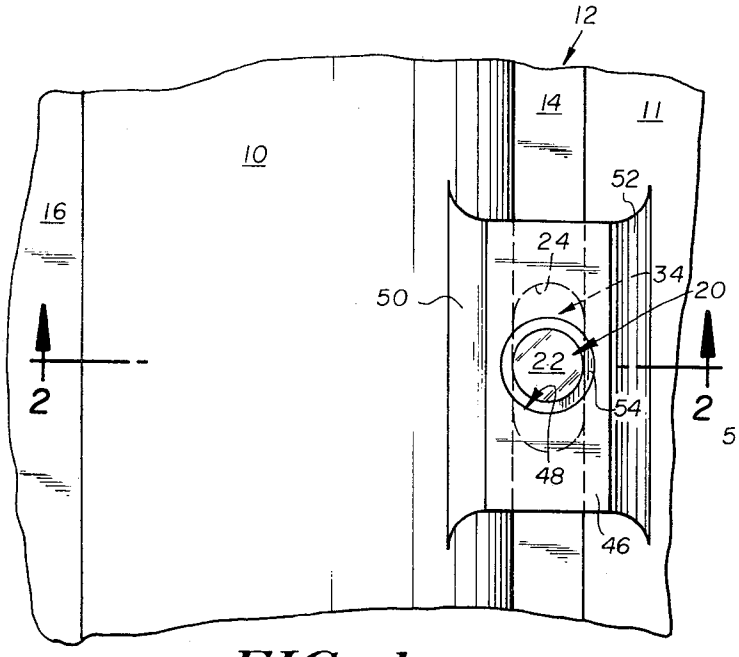


FIG. 1

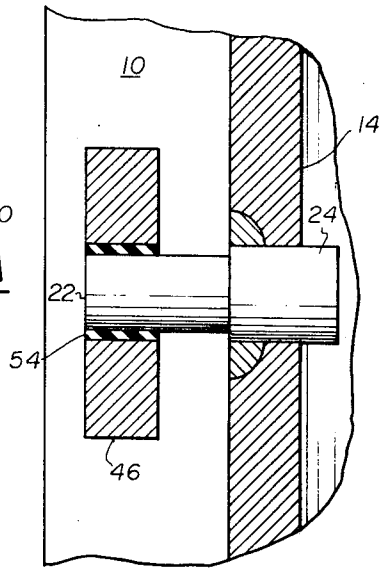


FIG. 3

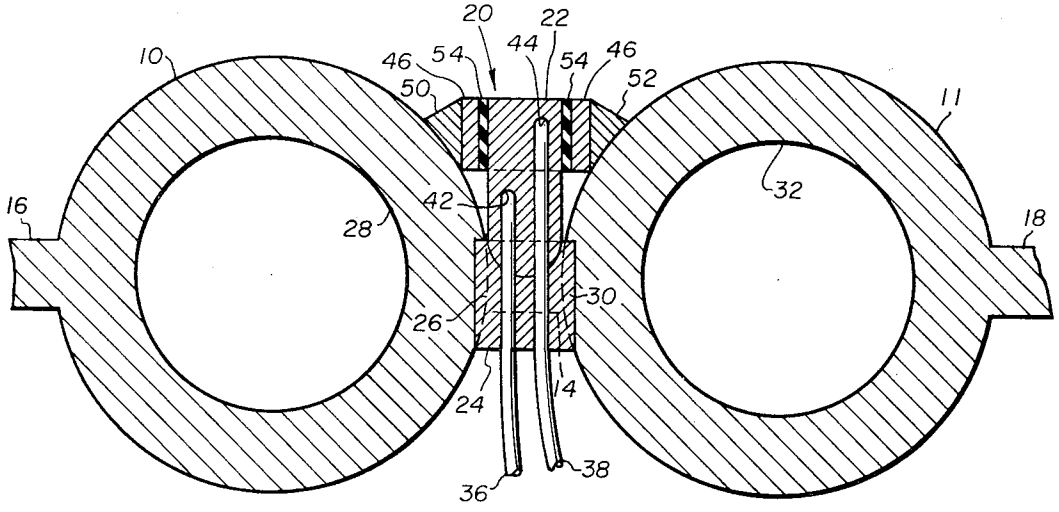


FIG. 2

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HEAT FLUX SENSING DEVICE

BACKGROUND OF THE INVENTION

There are many situations in industry where it is desirable to measure the amount of heat which is being absorbed by cooling tubes. An example is found in the operation of steam generators having furnace walls made up of parallel tubes which are joined by fins running longitudinally of the tubes. Typically, the fins join the tubes approximately in a plane through the longitudinal axes of the tubes so that the portions of each tube lying on either side of the fins are approximately equal.

In some installations, the amount of heat absorbed by the tubes is measured at a location by placing thermocouples in a metal heat pad which is welded from face center to face center of two adjacent tubes so that heat from the heat zone or firebox of the boiler will impinge on the pad. The thermocouples are placed in the pad a given distance apart so that the temperature difference over that distance can be used to calculate the heat flux.

Such an arrangement has several disadvantages. For one, the pad conducts heat to what is normally the hottest part of the tube. Consequently, both pad and tubes may overheat. In addition, the pad is relatively massive and therefore will expand to a greater extent than the adjacent fin which is less massive and at a lower temperature. The result is a tendency toward excessive stresses at the joints between the fin and tubes which are spanned by the metal pad.

Another way in which heat flux is measured in such a furnace wall is through thermocouples inserted at different depths in chordal holes in the tubes. Such an arrangement weakens the tube wall and increases the chances of leakage. It has been found that this arrangement is inherently inaccurate because of difficulty in accurately positioning the thermocouple junctions.

Still another method uses flux meters which are protected by a coolant. The practicability of this arrangement is limited by the fact that a separate coolant flow must be maintained for each meter and often an accurate measurement of flow and temperature rise is necessary if the heat flux is to be calculated.

SUMMARY OF THE INVENTION

It is the object of the present invention to overcome drawbacks found in the prior art, such as those discussed above. Accordingly, extending from between two parallel tubes toward the heat zone is an elongated heat conductor in which are embedded two thermocouples spaced a given distance part along its length. The heat will flow longitudinally through the conductor to a tube wall location spaced farther from the heat zone than the hottest portion of the tubes, whereby the thermocouples will indicate a temperature difference from which the heat flux can be determined.

A BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a fragmentary front view in an enlarged scale showing a preferred form of the present invention,

FIG. 2 is a view, partly in section, taken substantially along the line 2—2 of FIG. 1; and

FIG. 3 is a view showing the connections of the heat conductor to the heat shield and fin.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In FIG. 1, adjacent parallel cooling tubes 10 and 11 forming a portion of a furnace wall 12 are joined by a fin 14 which extends longitudinally of the tubes. The tube 10 is also joined to a fin 16 which connects to the tube immediately on the left of tube 10 (not shown). Similarly, the tube 11 is connected to the tube immediately to its right (not shown) by a fin 18. The furnace wall 12 is made up of many such tubes, each joined to the adjacent tube or tubes by fins. All of the fins join the contiguous tubes so that approximately one-half of the tube is positioned on one side of the fins, and half is on the other side. In other words, the inner portion of the tube, the portion which communicates directly with the heat zone is as large as the outer portion which defines the outside surface of the furnace wall.

An elongated heat conductor 20 comprising a pin portion 22 and a base portion 24 which is joined with each of the tubes 10 and 11 in the portions thereof which face each other. The base portion 24 has a side 26 which extends into a side portion 28 of the tube 10, and a side 30 which extends into a side portion 32 of the tube 12. The pin portion 22 extends from the base portion 24 and toward the inside of the furnace, that is, toward the heat zone.

The base portion 24 fits snugly in a hole 34 in the fin 14 and as shown in FIG. 2 the base portion 24 extends through the fin 14.

As shown in FIG. 3 the hole 34 is recessed along the periphery thereof on the inner side of the fin 14. This allows for a substantial weld bead 35 to be applied and provide a substantial heat conducting path between conductor 20 and fin 14.

Embedded in the heat conductor 20 are two thermocouples 36 and 38. The thermocouples 36 and 38 each extend from outside of the wall through the base portion 24 and terminate in the pin portion 22 at junctions 42 and 44 respectively. The junctions 42 and 44 are at different locations along the length of the pin section 22 so that they are different distances from the end of the pin portion 22 which faces the heat zone.

A radiation shield 46 having a hole 48 of a diameter larger than the pin portion 22 is welded along each of its sides at 50 and 52 to the tubes 10 and 11. The end of the pin portion 22 facing the heat zone is positioned coaxially within the hole 48 so that its face is flush with the face of the radiation shield. Because the hole 48 has a larger inside diameter than the pin portion 22, an annular space between the radiant heat shield 46 and pin portion 22 is present. Positioned in this space is a ring of insulation 54.

In practice, heat impinging upon the area between the tubes 10 and 11 which is not reflected or absorbed by the radiation shield 46 will pass longitudinally down the pin portion 22 of the heat conductor 20 and then through the base portion 24 into the fin 14 and thence into tubes 10 and 11. There will be little thermal stress exerted by the present flux sensing device because there will be little expansion of the conductor 20 in directions perpendicular to the tubes 10 and 11. This is so because unlike a heat pad the conductor 20 has no large dimensions in this direction. In addition, the conductor 20 is cooled because it conducts heat to a comparatively cool portion of tubes 10 and 11, that is, the portions which are adjacent to the fin 14.

The radiant heat shield **46** will also be subject to less stress than would a heat pad because it does not extend over the distance between face centers of adjacent tubes, and also because it connects to cooler portions of the tubes **10** and **11**.

Since the pin portion **22** is flush with the heat shield **46** and insulation **54**, heat will impinge only on the flat end surface of the pin portion **22**. The amount of heat flow per unit area, per unit time, that is, the heat flux, passing axially through the pin portion **22** will therefore be substantially the same as that passing through an equivalent area at or close to the face centers of the tubes. It should be noted that there will be no large difference in temperature between the end surface of the pin portion **22** and the face centers of the tubes to create an appreciable difference in heat flux entering those two elements.

Since the heat flows only axially through the pin portion **22**, the heat flux in the pin portion **22** can be accurately determined from the temperature gradient in that element. The temperature gradient can, of course, be determined from the temperature difference across the junctions **42** and **44**, which are a given distance apart along the axis of pin portion **22**.

Since the heat flux through the present heat flux sensing device is substantially the same as that passing through the areas of the tubes adjacent to their face centers, the heat absorption rate of the tubes is readily and accurately determinable.

It will be readily apparent to one of ordinary skill in the art that the above describes but one embodiment of the present invention and that it may be modified considerably without exceeding the scope thereof as defined in the following claims.

What is claimed is:

1. In combination, two parallel tubes for flowing a cooling fluid on one side of a heat zone, said tubes being joined by a fin extending longitudinally of and between said tubes, an orifice in said fin, a heat flux sensing device comprising an elongated conductor and two thermocouples within said conductor said conductor having an end in said heat zone and passing through said orifice to be connected to said fin at a location remote from said end, said thermocouples being disposed between said location and said end, each of said thermocouples having a junction, said two junctions being spaced from one another a given distance along the length of said conductor.

2. The structure defined in claim **1** further comprising a radiation shield bridging said two tubes, said shield having a hole, said hole being aligned with said conductor so that heat emanating from said heat zone will impinge against the end of said conductor.

3. The structure defined in claim **2** wherein said conductor comprises a pin portion and a base portion, said base portion being positioned within an aperture in said fin, and said pin portion extending from said base portion toward said heat zone, said junctions being in said pin portion.

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