June 7, 1938. P. R. CASSIDY ET AL 2,120,125

FLUID HEAT EXCHANGE APPARATUS

Original Filed Jan. 20, 1934 2 Sheets-Sheet 1

Fig. 1

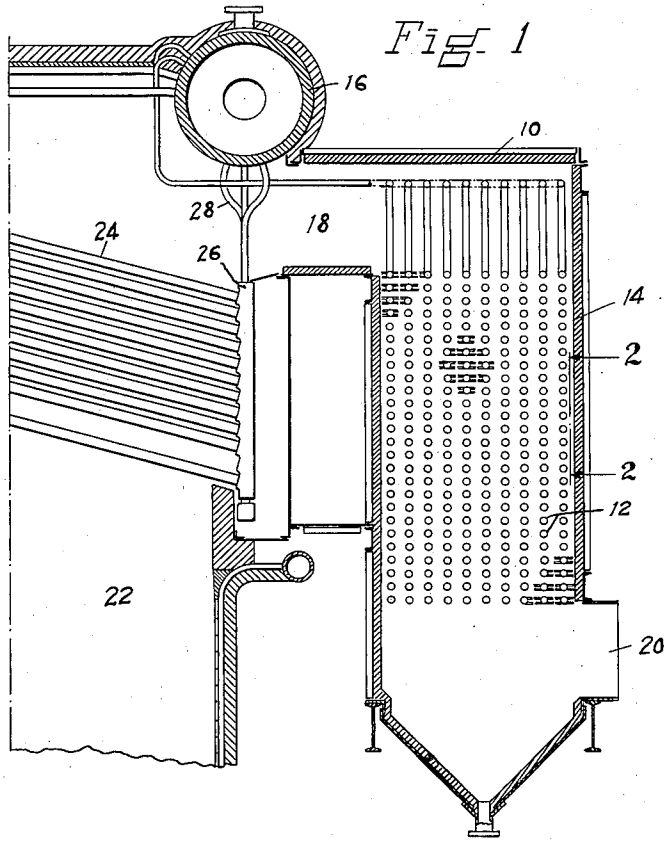
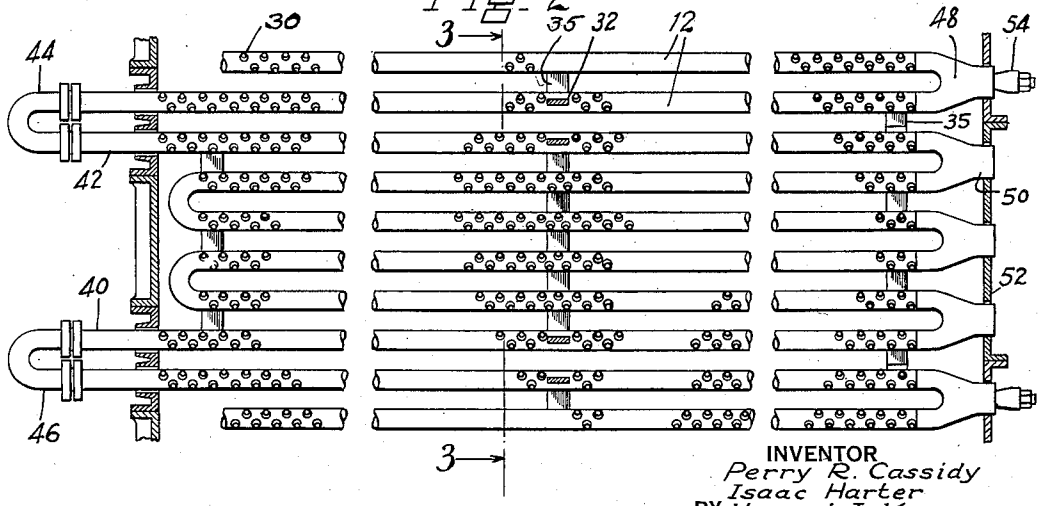


Fig. 2



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Fig. 3

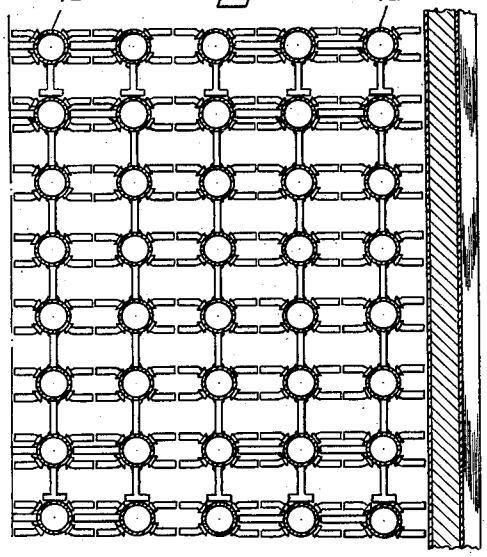


Fig. 4

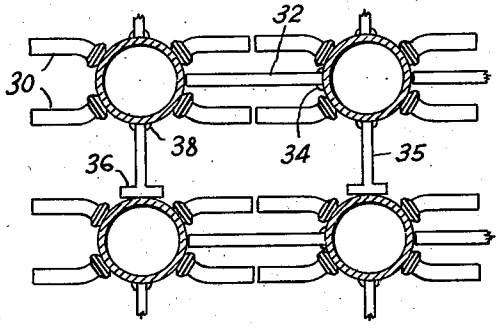


Fig. 5

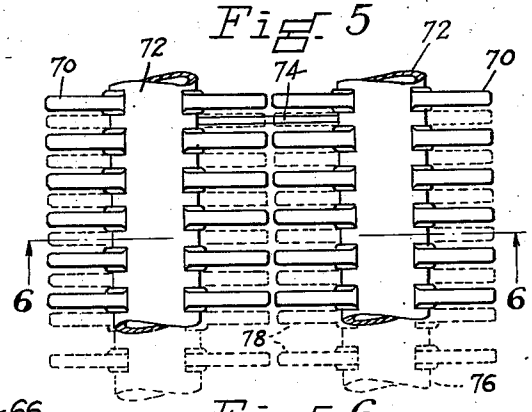


Fig. 10

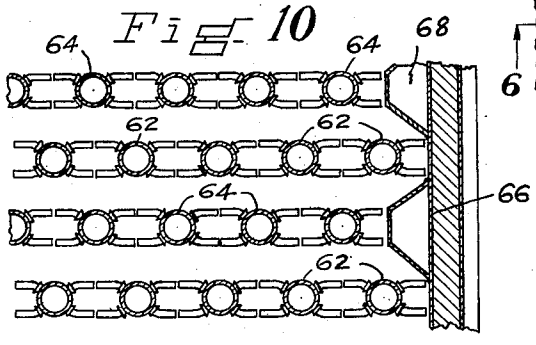


Fig. 6

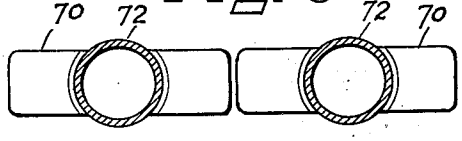


Fig. 7

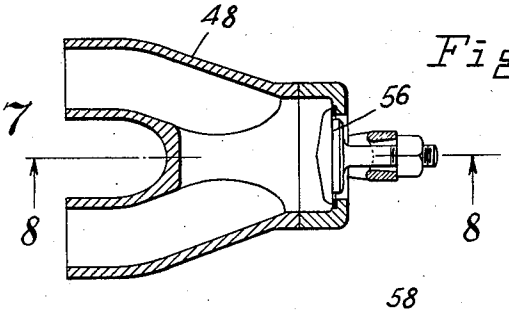


Fig. 9

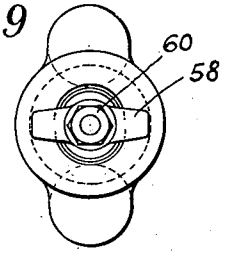
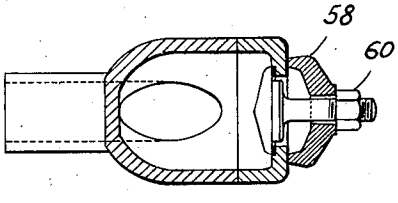


Fig. 8



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UNITED STATES PATENT OFFICE

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FLUID HEAT EXCHANGE APPARATUS

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Application January 20, 1934, Serial No. 707,442
Renewed June 9, 1936

20 Claims. (Cl. 257—220)

This invention relates to fluid heat exchange apparatus and it is here described with reference to an economizer used in connection with a steam boiler to raise the temperature of feed water by transferring heat thereto from furnace gases after they have passed over the steam generating surfaces of the boiler, and where desired to generate steam after the water has reached its boiling point.

It is an object of the invention to provide an extended surface economizer in which the tubes do not divert the gas flow so that the extended surface elements are rendered ineffective on account of being positioned in a tube flow shadow.

A further object of the invention is to provide an economizer with studded water tubes of such characteristics that effective water heating may be accomplished without preventing the economizer tubes from contacting with the furnace gases.

A further object of the invention is to provide extended surface structure having effective heat transfer capacity at the tube junction by welding and by cross-section of weld, of a construction that is inexpensive and that does not impose stresses on tubes or surface by the act of welding sufficient to harm either member or the joint.

Other objects will appear as the accompanying description proceeds.

The invention will be described with reference to the accompanying drawings, in which:

Fig. 1 is a view in the nature of a diagrammatic view showing the illustrative economizer in operative relation to a steam boiler.

Fig. 2 is a view in the nature of a vertical section taken on the line indicated as 2—2 in Fig. 1, and looking in the direction of the arrows there shown and illustrating the ends of circular section studs.

Fig. 3 is a vertical section of an economizer taken on the line 3—3 of Fig. 2, and along a plane at right angles to the plane in which Fig. 2 is taken.

Fig. 4 is a detail view showing the relationship of a few of the economizer tubes with the longitudinal and transverse spacing struts between the tubes.

Fig. 5 is a detail view of an embodiment of the invention in which the economizer tubes are provided with studs of rectangular instead of circular section.

Fig. 6 is a vertical sectional view taken on the line 6—6 of Fig. 5.

Fig. 7 is a detail view showing one of the economizer tube end Y-connectors indicated in Fig. 2.

Fig. 8 is a detail view in the nature of a horizontal section taken on the line 8—8 of Fig. 7.

Fig. 9 is an end elevation of the Y-connector shown in Figs. 7 and 8.

Fig. 10 is a vertical section showing a modified form of economizer in which the economizer tubes with their rows of integrally attached studs are staggered with respect to each other.

The economizer 10 indicated in Fig. 1 of the drawings is a countercurrent economizer in which the water enters a series of tubes 12 at the base of an economizer casing 14. As the water proceeds in a zig-zag manner upwardly through these tubes to the boiler drum 16, it is heated by furnace gases proceeding downwardly from the boiler outlet 18 to the stack opening 20 at the base of the economizer casing. The boiler parts indicated in Fig. 1 include a furnace 22 which is situated below a bank of horizontally inclined steam generating tubes 24. The generating tubes are connected at their lower ends to a header construction 26 of known form, the header being connected with the water space of the drum 16 by downtake nipples 28 extending across the path of gases as they proceed from the boiler to the top of the economizer flue.

An arrangement of economizer tubes is indicated in Figs. 3 and 4 of the drawings. As shown here, the tubes are provided with metallic studs 30 of circular section which are preferably electrically resistance welded to the tubes while held in radial position. There are two rows of studs on each of the opposite sides of the tubes, and the studs in successive vertical rows are staggered with respect to each other as clearly indicated in Fig. 2 of the drawings. After the studs are welded to the tubes they are bent so that their outer ends extend horizontally, or in a direction normal to the gas flow axis of the economizer and across the space between adjacent tubes. This arrangement of the studs is quite clearly shown in Figs. 3 and 4 of the drawings.

The studs 30 projecting horizontally from adjacent tubes terminate at positions about midway of the space between those tubes, and the tubes are held properly spaced horizontally by struts 32 extending transversely of the tubes and each having one end welded to the tubes as shown at 34 in Fig. 4. Adjacent tubes in the same horizontal row are thus held so spaced that the studs of those tubes cannot contact with each other, or overlap, and so are free to expand without stressing the tubes.

Adjacent economizer tubes in the same vertical

row are held in their operative positions by struts **35** extending transversely of the tubes and having T-shaped foot parts **36** at their lower ends as indicated in Fig. 4. They are preferably welded at their upper ends to the lower sides of some of the tubes as indicated at **38**, while their T-shaped lower ends rest upon adjacent tubes. In this way, the individual tube lengths of a coil or loop of return bend tube are held in their operative positions. As indicated in Fig. 2 of the drawings there are six of these tube lengths connected by return bends to form a single return bend coil. The end tubes **40** and **42** of these coils are connected to similar coils above and below them by removable return bends **44** and **46**. At the other wall of the economizer flue adjacent tube lengths of the return bend coils are joined by Y-connectors **48** having stems **50** extending through openings in the wall **52** of the economizer flue. Some of the return bend connectors are provided with hand-hole openings which are closed by hand-hole fittings **54**. These are shown in detail in Figs. 7, 8 and 9 where it is indicated that each fitting consists of a valve member **56** and a bridge piece **58** against which the nut **60** may be turned to close the opening in the Y-connector.

In Fig. 10 of the drawings the tubes **62** in alternate horizontal rows are staggered with respect to the tubes **64** of adjacent rows. This arrangement also effects a staggering of the studs arranged between successive rows. At the economizer wall **66** there are filler members **68** secured to the wall and extending to positions adjacent the ends of the studs secured to the tubes **64** in order to limit short circuiting of gases.

In either one of the embodiments of the invention there is sub-division of the heating gases to such a high degree by the large number of closely spaced small diameter studs that a relatively small number of the studded tubes may have the heat transfer effectiveness of a much larger number of tubes used without the studs. Also, in the form of extended surface economizer here shown, a considerable proportion of the bare tube surface is left freely exposed to contact with the heating gases. The extended surface elements and the economizer tubes are also so arranged that none of the extended surface elements are in the tube shadows, or the gas eddies that form on the down stream sides of transversely swept tubes. Furthermore, an increase in heat transfer rate attends the arrangement of the studs between the tubes at the point of maximum gas velocity. By reason of this location of the extended surfaces there is a further increase of gas velocity at the previous point of maximum velocity, as well as the attendant increase in rate of heat exchange.

Figs. 5 and 6 indicate an embodiment of the invention in which metallic vanes or blades **70**, constituting rectangular section studs, are electrically resistance welded to the economizer tubes **72**. These rectangular section studs may be welded to the tubes along opposite sides and they may be arranged in pairs directly opposite each other as shown. This form of invention reduces the total number of welding operations required to form a given percentage of extended surface. In this embodiment of the invention, successive tubes in a vertical row may be spaced in the same manner as are the tubes of the Fig. 3 modification. Narrower struts **74** space the tubes in the horizontal rows.

Fig. 5 shows an arrangement of economizer elements wherein the vanes on successive tubes in the vertical rows are staggered with respect to each other. As here shown the tube **72** lies above the tube **76** and the studs **78** of the latter are staggered with respect to the vanes **70** of the upper tubes **72**.

In some cases it is advantageous to place studs so as to point toward the direction from which the gases are approaching, when the tube spacing vertically is great enough so that they are not in tube shadows, and they may be used to supplement side studs or to replace them.

Although the invention has been described with reference to the particular embodiments of the invention shown in the drawings, it is to be understood that it is not limited thereto, but that it is of a scope commensurate with the scope of the sub-joined claims.

What is claimed is:

1. In an extended surface economizer, a heating gas flue, water tubes in the flue, and transverse metal bars welded to opposite sides of the tubes, the tubes being arranged in rows extending transversely of the flue with the bars of the tubes of a row disposed between parallel planes transverse to the flue and bounding the tubes of the row, and the bars on successive tubes along the path of gas flow being disposed in staggered relationship.

2. In an extended surface counterflow economizer, a heating gas flue, water tubes in the flue, and transverse metal bars end welded to opposite sides of the tubes, the tubes being arranged in rows extending transversely of the flue with the bars of the tubes of a row disposed between parallel planes transverse to the flue and bounding the tubes of the row, the bars having a maximum width which is less than the diameter of the tubes.

3. In an economizer, a flue for heating gases, water conducting tubes extending across the flue and having more than 50% of their bare tube surface exposed directly to heating gases, and spaced cylindrical metallic studs outside of the tube shadows and welded to the tubes to project therefrom into the heating gases and transversely of their flow, said studs being disposed substantially wholly within the inter-tube spaces between adjacent tubes in the same transverse row and between pairs of parallel transverse planes bounding said rows of tubes.

4. In an economizer, successive horizontal and upright rows of water tubes, and metallic vanes positioned outside of the tube shadows and welded to the opposite sides of the tubes at spaced positions thereon, the vanes on successive tubes in upright rows being staggered with respect to each other, said vanes being disposed substantially wholly within the inter-tube spaces between adjacent tubes in each of the horizontal rows and between parallel planes bounding the individual horizontal rows.

5. In an economizer, successive horizontal rows of water tubes, and metallic vanes welded to the tubes at spaced positions thereon and positioned outside of the tube shadows, the vanes on successive tubes being staggered with respect to each other, said vanes being disposed substantially wholly within the inter-tube spaces between adjacent tubes in each of the horizontal rows and between parallel planes bounding the individual horizontal rows.

6. In an economizer, a flue for heating gases, water tubes extending across the flue and arranged in upright as well as horizontal rows, return bends and Y-connectors joining successive

tubes in the upright rows so as to form flat coils or slabs of return-bend tubes, removable return bends connecting the successive coils, rows of staggered metallic studs welded to opposite sides of the tubes so as to extend transversely of the flue, upright struts welded to the tubes and positioned between successive tubes in an upright row, and horizontal struts interposed relative to successive tubes in the horizontal rows and welded thereto to maintain the studs of those tubes out of contact.

7. In an economizer, a flue for heating gases, water tubes extending across the flue and arranged in upright as well as horizontal rows, rows of staggered metallic studs welded to opposite sides of the tubes so as to extend transversely of the flue, upright struts welded to the tubes and positioned between successive tubes in an upright row, and horizontal struts interposed relative to successive tubes in the horizontal rows and welded thereto to maintain the studs of those tubes out of contact.

8. In an economizer, a flue for heating gases, water tubes extending across the flue and arranged in longitudinal as well as transverse rows, rows of staggered metallic studs welded to opposite sides of the tubes so as to extend transversely of the flue, and transverse struts interposed relative to successive tubes in the transverse rows and welded thereto to maintain the studs of those tubes out of contact.

9. A stud tube economizer comprising, a flue, a plurality of water tubes disposed in a plurality of rows extending transversely of the flue with the flue gases moving transversely of the tubes, and headed studs disposed between the tubes of the rows and outside of the tube shadows thereby leaving the inter-row spaces free, the studs being welded to the tubes at their headed ends and extending transversely of the flue as well as the tubes.

10. A stud tube economizer comprising, a flue, water tubes in spaced rows arranged both transversely and longitudinally of the flue, and headed studs welded to the tubes along their sides bounding the spaces between the longitudinal rows and positioned outside of the tube shadows and the spaces between the transverse rows.

11. An extended surface economizer comprising, in combination, a flue for heating gases, water conducting tubes in the flue, and staggered metallic studs welded to the tubes and entirely positioned in the most active gas flow zones.

12. In an extended surface economizer, a gas flue, water tubes in spaced rows arranged transversely of the flue, and metallic studs welded to the tubes so as to extend only across the gas flow space between adjacent tubes in contact with furnace gases, the spaces between the transverse rows of tubes being free.

13. In an extended surface economizer, a heating gas flue, successive rows of tubes arranged transversely and longitudinally of the flue with gas flow lanes between them, and transverse metal studs welded to opposite sides of the tubes with the studs of the tubes of a row disposed between parallel planes extending transversely of the flue and bounding the tubes of the row, all of the active surface extensions formed by the studs projecting from the tubes toward each other across the gas flow lanes.

14. In an extended surface economizer, a flue for heating gases, water conducting tubes spaced in rows arranged transversely and longitudinally of the flue, and metallic vanes or blades constituting extended surface metal elements welded to opposite sides of the tubes so as to extend transversely of the longitudinal axes of the tubes in contact with furnace gases, the vanes on successive tubes being staggered and all of the economizer heating surfaces provided by the tubes and vanes being disposed in a succession of spaced transverse zones with free spaces between the zones.

15. In fluid heat exchange apparatus, means forming a pass for the flow of a heat exchange fluid, a bank of tubes extending across the pass and arranged in rows arranged transversely of the flow of said heat exchange fluid, extended surface metallic studs welded to the tubes and positioned wholly within the zones of maximum velocity of the heat exchange fluid so as to leave the spaces between said transverse tube rows free of obstruction by the tubes or the studs and to cause maximum heat exchange with a minimum of extended surface, and means extending across said spaces between the transverse tube rows and engaging the tubes to maintain them in their transverse row relationships.

16. In fluid heat exchange apparatus, means forming a pass for the flow of a heat exchange fluid, a bank of tubes extending across the pass and arranged in rows arranged transversely of the flow of said heat exchange fluid, and extended surface metallic studs welded to the tubes and positioned wholly within the zones of maximum velocity of the heat exchange fluid so as to leave the spaces between said transverse tube rows free of obstruction by the tubes or the studs and to cause maximum heat exchange with a minimum of extended surface.

17. In fluid heat exchange apparatus, means forming a pass for the flow of a heat exchange fluid, a bank of tubes extending across the pass and arranged in rows disposed transversely of the flow of said heat exchange fluid, extended surface metallic studs welded to the tubes and positioned wholly within the zones of maximum velocity of the heat exchange fluid so as to leave the spaces between said transverse tube rows free of obstruction by the tubes or the studs and to cause maximum heat exchange with a minimum of extended surface, and means extending across said spaces between the transverse tube rows and engaging the tubes to maintain them in their transverse row relationships, the studs extending toward each other from adjacent tubes in the same transverse row having full width ends facing each other so as to limit the extent to which the tubes may move transversely from their original positions.

18. In an extended surface economizer, means forming a gas pass, tubes of cylindrical cross-section arranged within said gas pass for transverse flow of the gas with respect thereto, and separate extended surface elements projecting from each tube across the path of gas flow and disposed on both sides of the axial center line on each tube, said extended surface elements being spaced in the direction of gas flow on each tube.

19. In an extended surface economizer, means forming a gas pass, spaced tubes of cylindrical cross-section within said gas pass and arranged for transverse flow of the gas with respect thereto, and separate extended surface elements welded to each tube so as to extend across the path of gas flow and disposed on both sides of the axial center line of each tube, said extended surface elements being spaced in the direction of gas flow on each tube and arranged so that the adjacent

ends of elements extending toward each other from adjacent tubes are in confronting relationship.

20. An economizer acting to preheat the feed water before it enters the main steam generating section of a water tube steam boiler and comprising, in combination, a bank of spaced tubes extending transversely of the flow of furnace gases passing from said steam generating section, and small rod-like metallic studs supported by and in good heat transfer relation with said tubes, said studs extending transversely of the direction of gas flow with facing surfaces of successive tubes in that direction bare of studs, successive tubes transversely of the gas flow having their studs spaced and extending normally to the direction of gas flow and terminating at positions substantially midway between said tubes.

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