

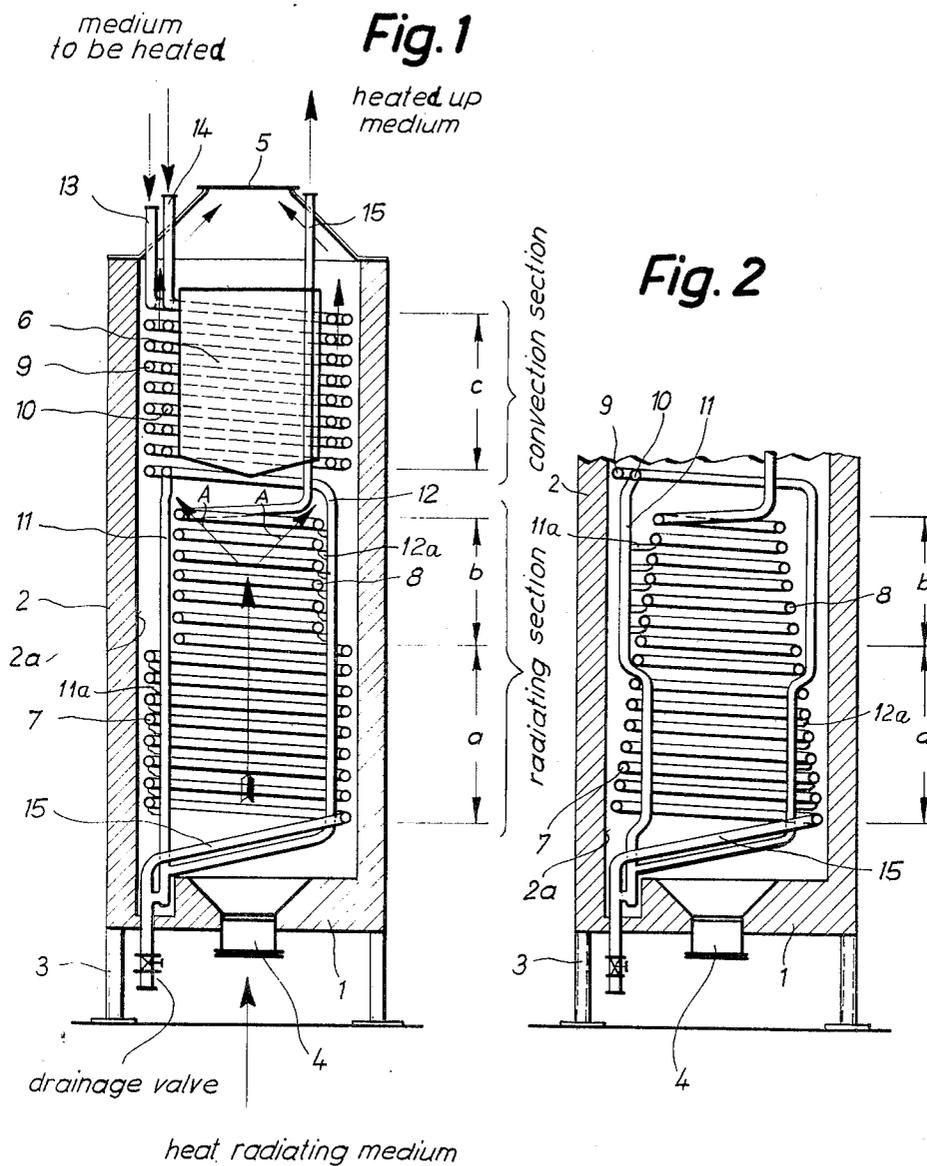
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RECUPERATOR WITH HELICAL COILS

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**RECUPERATOR WITH HELICAL COILS**

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The present invention relates to a recuperator in which the heat radiation and convection sections are formed by helical coils arranged one behind the other when looking in the direction of flow of the heat flow of the heat radiating medium. In the case of heaters for gaseous media, particularly for such media which contain hydrocarbons, the use of helical coils of equal external diameter for both the convection and the radiation sections is known. It is also known respectively to select different coil diameter for the coils of the convection section and for the coils of the radiation section. It is furthermore known to use a plurality of concentrically arranged helical coils for the convection section. It has also been proposed to use helical coils for recuperators, each coil being helically wound in one plane.

It is an object of this invention to provide an improved recuperator of the general type referred to above while considering the high temperatures of the heat radiation medium entering the recuperator and also taking into consideration the cooling down of said medium due to its transmitting heat to the heat absorbing medium and to the parts of the recuperator.

It is a further object of this invention to provide a recuperator of the type set forth above, in which the coils are so arranged that only a relatively small portion of the burner or flue gases representing the heat radiating medium will pass by the outside of those coils which are adjacent the entrance portion of the burner or flue gases into the exchanger.

It is still another object of this invention to provide a recuperator as set forth above, which will make it superfluous to employ the heretofore required supporting blocks and intermediate webs between successive coils.

These and other objects and advantages of the invention will appear more clearly from the following specification in connection with the accompanying drawing diagrammatically illustrating a vertical section through a recuperator according to the present invention.

When employing austenitic materials which are rather expensive and are characterized by their considerable expansion under the influence of heat, a uniform exposure to heat is most important in order to obtain a uniform service condition and a uniform utilization of the material. In order to obtain a substantially uniform expansion of the coils of the recuperator, according to the present invention, the windings of the coils of the radiation section of the recuperator respectively have different diameters. The arrangement is such that those windings which have the larger diameters are arranged near the inner wall of the recuperator and ahead of the windings of smaller diameter, when looking in the direction of flow of the heat radiating medium. By arranging the windings of larger diameter near the inner wall of the recuperator body, only a relatively small percentage of the burner or flue gases constituting the heat radiating medium is brought into contact with the outwardly facing surface of those windings of the coils which are located adjacent the inlet opening for the burner or flue gases of the recuperator. The heat transfer, therefore, takes

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place primarily on the inner portion of the coil cross section within that portion of the radiation section of the recuperator which is subjected to the highest temperature of the heat radiating medium. While in this portion of the radiation section the burner or flue gases are relatively hot, the medium to be heated up in the coils is still relatively cold. In this way the wall temperatures in the coil section which is unilaterally acted upon by the flue or fire gases are not too high. The coil windings of smaller diameter of the radiation section are spaced farther from the burner or flue gas feeding passage. While here the flue or fire gases are relatively cool having been cooled by the coils of the preceding radiation section, the temperature of the medium to be heated in the coils has here reached its maximum value. Consequently, in this section of the heat exchanger, also the highest value of the wall temperature and thus the highest stress of the material will be encountered. Due to their small winding diameter, the pipes are swept over their complete circumference by the heat radiating medium and are thus subjected to a uniform temperature stress. In that section of the recuperator which contains the coils of smaller diameter, a portion of the heat transfer will be effected by convection so that in said last mentioned section, so to speak, a mixed heat transfer—radiation and convection—will occur. Advantageously, the coils of the radiating section are subdivided into successive groups with windings of the same diameter. In addition to bringing about advantages as to manufacture, such an arrangement also has the advantage that the vertical connecting sections between the convection section and the radiation section may be passed between the groups of different winding diameters of the coils. Expediently, between the convection section and the radiation section, two connecting pipes are provided which are diametrically oppositely located with regard to the longitudinal axis of the recuperator. It is on those diametrically oppositely located connecting pipes that the coils of the radiating section are suspended. This solves the problem of the suspension or support of the windings of different diameters of the radiating section, because it is then no longer required to employ supporting blocks or the like or the heretofore known webs between successive windings of the coils, which blocks or webs have to be machined very precisely in order to assure a proper effect and operation of the parts.

Referring now to the drawing in detail, the recuperator illustrated therein and generally designated R comprises a cylindrical body 2 with a bottom 1 resting on legs 3. Bottom 1 is provided with an opening 4 for a burner or for the introduction of a heat radiating medium. The heat radiating medium in form of fire gases, burner gases or heating gases passes through the interior of the body 2 in the direction from the bottom to the top and leaves said body 2 through an opening 5 at the upper end of the body 2.

Arranged within the interior of the body 2 there are helical coils 7, 8, 9 and 10 which are subdivided into sections a, b and c. Those coils in sections a and b which are passed through by a medium to be heated form the radiation section, whereas the section c at the level of which within the windings of said coils there is arranged a displacement body 6, forms the convection section. Within the section a of the radiation section, coil windings 7 are arranged near the inner wall 2a of the body 2 whereas the coils 8 of the section b are spaced from the inner wall 2a by a much greater distance than coils

7 so that their outer diameter is considerably less than the outer diameter of the coils 7 in section *a*.

The arrangement of coils 7 and 8 is such that the burner or heating gases in section *a* act substantially only upon the inwardly pointing surfaces of the coils, whereas the coils 8 of section *b* have their inwardly and outwardly pointing surfaces swept by the burner or heating gases. Whereas the hot burner or heating gases in section *a* act upon a portion only of the circumferential area of the coils, it will be evident from the drawing that in section *b* a considerably larger portion of the circumferential area of coils 8 will be swept by the hot burner or heating gases. Here the burner or heating gases are cooler than in section *a* so that approximately the same change in the longitudinal direction of the coils 7 and 8 will occur in view of the temperature of the heating or burner gases prevailing in section *a* and in section *b*. While at the lower end of section *b* the heat transfer is effected almost exclusively by radiation, in the upper portion of said section the heat is transferred more or less by radiation and by convection. The convection section in section *c* is formed by two coils 9 and 10 which are arranged coaxially with regard to each other. In order to exploit the burner or heating gases as far as possible, the coils 9 and 10 have different diameters with regard to the windings of the coils 7 and 8.

The shape and arrangement of coils 7 and 8 may be so selected that a conical pipe bundle will be obtained while in contrast to the arrangement illustrated in the drawing, no step will be formed between the sections *a* and *b*, as to be seen in FIG. 2.

When the difference between the winding diameters of coils 7 and 8 is so selected that the vertical connecting pipes 11 and 12 between the ends of the convection section *c* and the start of the radiation section *a* are arranged diametrically opposite to each other and if said connecting pipes 11 and 12 at the level of section *b* are arranged outside the coil windings 8 and at the level of section *a* inside the coil windings 7, the arrangement according to the present invention has a particular advantage. More specifically, in such an instance the coils 7 and 8 are supported by brackets 11*a* and 12*a*, which are connected to pipes 11 and 12 in any convenient manner, for instance, by welding or brazing. This brings about the advantage that the entire inner portion of the recuperator does not require any support on the body 2, and that the occurring expansions of the coils between the support of the coils and the sleeves or bushings for passing therethrough the inlet and outlet pipes 13, 14, 15 for the medium to be heated up will require no special compensating means.

The medium to be heated up passes through the two inlet connections 13, 14 into coils 9 and 10 respectively of the convection section *c* in which it passes in counter-current to the heat radiating burner or heating gases which sweep the coils 9 and 10 in the direction of the arrows *A* shown in the drawing. From the lower end of the convection section *c* the medium to be heated up is passed respectively through the two pipes 11 and 12 to the lower end of portion *a* of the radiation section where the two flow through pipes 11 and 12 unite in pipe 15 connected to coil 7 and then pass from there likewise in a manner known per se in the same direction as the heating medium to the discharge pipe 15.

It is, of course, to be understood that the present invention is, by no means limited to the particular construction shown in the drawing, but also comprises any modifications within the scope of the appended claims.

While the pipes 7 and 8 may be connected to the pipes 11 and 12 in any convenient manner, a connection by welding or brazing has proved successful.

What I claim is:

1. A recuperator which includes a tubular body having one end thereof provided with an inlet to admit a heat

radiating medium into said tubular body and having its other end provided with an outlet for discharging said medium from said tubular body, said tubular body having a straight cylindrical inner surface, a first set of helically coiled pipe means arranged within said tubular body near said outlet and being spaced from the inner wall of said tubular body, a second set of helically coiled pipe means arranged within said first set of helically coiled pipe means in spaced relationship thereto so as to leave an annular passage therebetween, conduit means extending into said body at the outlet end thereof for supplying a medium to be heated to said first and second sets of pipe means and connected to the end of said first and second sets which is adjacent said outlet, a third and a fourth set of helically coiled pipe means interposed between said first and second sets of helically coiled pipe means and said inlet, said third and fourth sets being substantially axially aligned with regard to each other while said third set is interposed between said fourth set on one hand and said first and second sets on the other hand, the outer periphery of said fourth set being spaced from the inner wall of said tubular body, said third set having an outer diameter less than the outer diameter of said fourth set, tubular conduit means connected to the end of said fourth set which is adjacent said inlet, first and second tube means connected to the respective ends of said first and second sets which are remote from said outlet and passing along the outside of said third set and along the inside of said fourth set and communicating with said tubular conduit means, said third and fourth sets being interconnected at their adjacent ends, and a discharge conduit connected to the end of said third set which is remote from said fourth set and extending along inside said first and second sets to and through the said outlet end of said body.

2. A recuperator according to claim 1 which includes: a cylindrical body disposed inside said second set of helically coiled pipe means coaxially therewith and in radially spaced relation thereto, thereby to define with the inner surface of said tubular body an annular space in which said first and second sets of helically coiled pipe means are located and through which space the said heat radiating medium passes during the movement thereof from said inlet to said outlet.

3. A recuperator which includes: a tubular body having one end thereof provided with an inlet to admit a heat radiating medium into said tubular body and having its other end provided with an outlet for discharging said medium from said tubular body, said tubular body having a straight cylindrical inner surface, and helical coil means arranged within said tubular body for receiving fluid to be heated by said heat radiating medium, said coil means comprising a convection section and a radiation section, said radiation section being connected in series with and located behind said convection section when looking from said outlet to said inlet, the coil means of said radiation section comprising a first set of coils and a second set of coils of lesser outer diameter than said first set of coils, said second set of coils being interposed between said first set of coils and said convection section, pipe means arranged within said tubular body near said other end and adapted to connect said convection section with a source of fluid to be heated, tube means connecting the other end of said convection section with said radiation section adjacent said one end of said tubular body and comprising a pair of tubes extending parallel to said surface on diametrically opposite sides of said body along the outer periphery of said second set of coils and along the inner periphery of said first set of coils and supporting said coil means of said radiation section, and discharge pipe means leading from said radiation section from the end thereof opposite the connection of the radiation section to said tube means.

4. A recuperator as defined in claim 3, in which said

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discharge pipe means extends through said convection section to the exterior of said tubular body.

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