Feb. 15, 1927. 1,617,519

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APPARATUS FOR SUPERHEATING STEAM BY MEANS OF A HIGH PRESSURE MEDIUM

Filed June 4, 1921 3 Sheets-Sheet 1

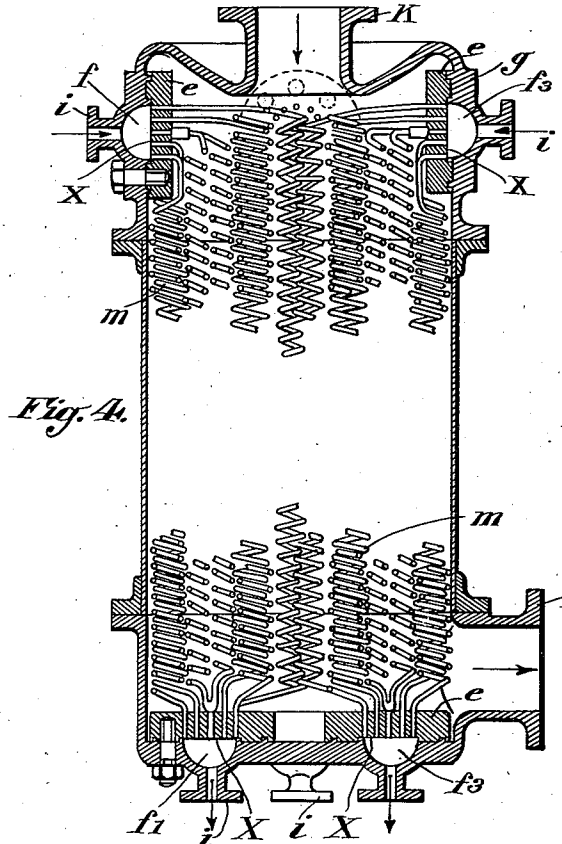


Fig. 4.

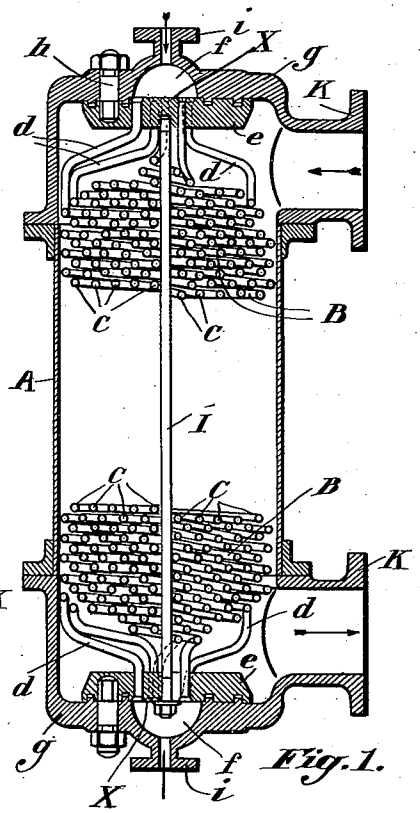


Fig. 1.

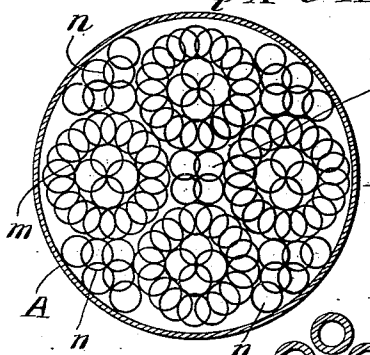


Fig. 6.

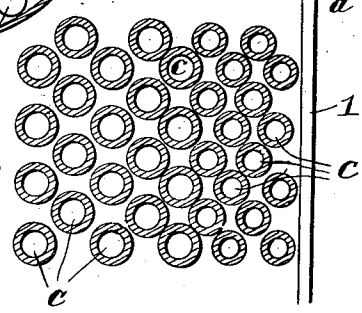


Fig. 2.

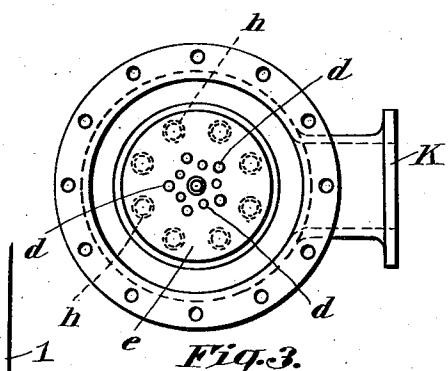


Fig. 3.

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Fig. 7.

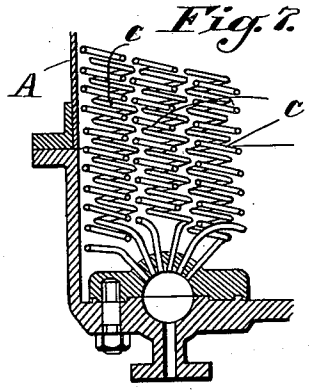


Fig. 9.

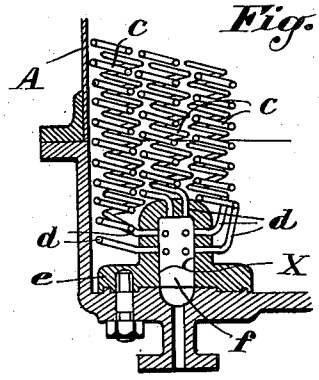


Fig. 8.

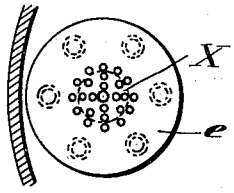
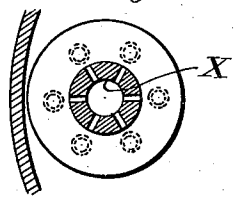


Fig. 10.



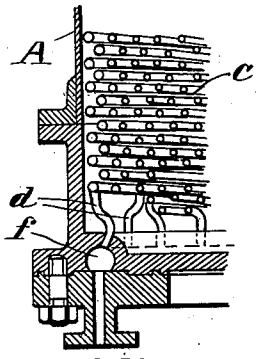


Fig. 11.

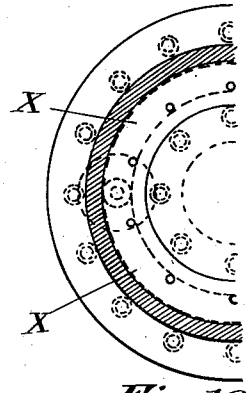


Fig. 12.

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APPARATUS FOR SUPERHEATING STEAM BY MEANS OF A HIGH PRESSURE MEDIUM

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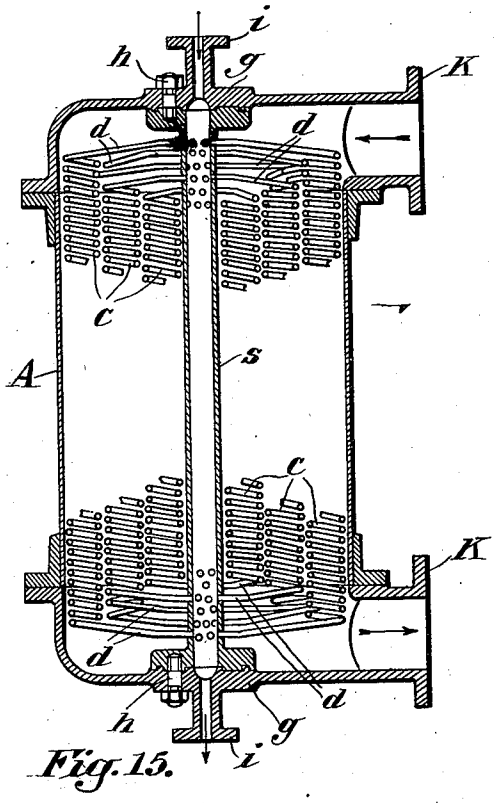


Fig. 15.

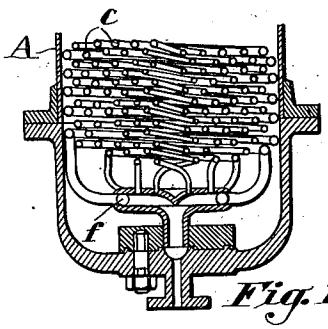


Fig. 13.

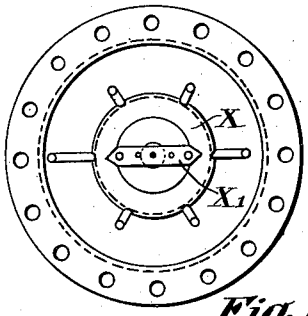


Fig. 14.

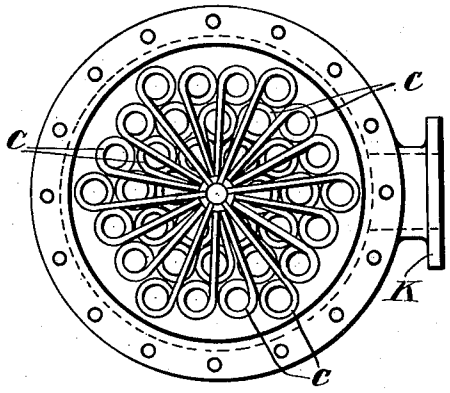


Fig. 16.

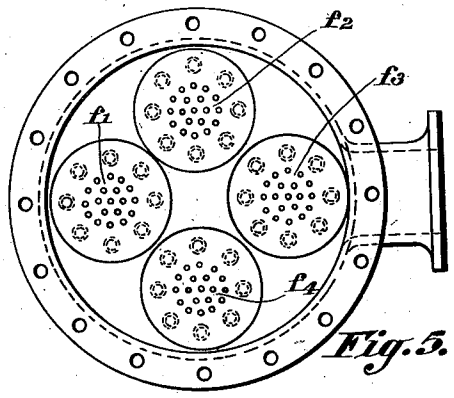


Fig. 5.

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR SUPERHEATING STEAM BY MEANS OF A HIGH-PRESSURE MEDIUM.

Application filed June 4, 1921, Serial No. 475,172, and in Germany September 24, 1919.

(GRANTED UNDER THE PROVISIONS OF THE ACT OF MARCH 3, 1921, 41 STAT. L., 1313.)

The invention relates to improvements in apparatus for superheating steam by means of a high-pressure medium flowing through a tube system arranged in a container through which passes the steam to be superheated.

The forms of apparatus of this type suggested hitherto have not satisfactorily fulfilled the necessary practical requirements, the chief of which are: the provision of a large heating surface in a small space; simplicity and ease of production; and ready accessibility for cleaning purposes.

In general the only suitable heating media for the purpose in question are water under high pressure or the steam therefrom, which for any practically useful degree of superheat must possess a pressure of at least 30 atmospheres corresponding to a temperature of 233° C.

With the objects in view, it is natural to employ a still higher pressure and temperature, for example, 100 atmospheres or even 150 atmospheres and more, corresponding in the case of water to a temperature of 300° and 340° respectively.

The heating surfaces for giving off the heat required for superheating with high pressures of the order above mentioned, must necessarily be constructed as tube systems in order to provide the necessary strength, the arrangement being preferably such that the high-pressure heating medium flows through a tube system immersed in the steam to be superheated.

In order to satisfy the requirement of small space in conjunction with large heating surfaces, the tubes must be of small bore and the individual tubes or coils must be arranged as close together as possible in order to reduce the cross-sectional area available for flow of the steam to be superheated, so that the latter attains a high velocity and is subjected to a considerable degree of agitation. The number of tubes or coils of tubes to be dealt with, each with its inlet and outlet end, is thus considerable, even when the quantity of steam to be heated is small.

The principle on which the present invention is based consists in inserting the ends of the tubes of a tube system arranged in a container into inlet or outlet chambers in such a way that the walls and fastenings of the latter are subjected to the least possible stress, so that they may be of minimum dimensions, a practicable heat-transmission apparatus in a compact form being thus ensured.

The above principle is realized in practice by closely packing the ends of the tubes arranged in a container into the walls of suitable inlet and outlet chambers in such a way that the area of the surface in which the open ends of these tubes lie is itself considerably less than the cross-section of the tube system.

By the expression "cross-section of the tube system" is to be understood the area enclosed by the outer limiting lines of the tube system in a plane perpendicular to its longitudinal axis.

In this manner, the inlet and outlet chambers which are under high pressure can be given small dimensions, the manufacture of the apparatus being thereby facilitated owing to the elimination of impracticable thicknesses of metal.

In addition the tube systems are connected together in one or more groups so that they may be readily removed for cleaning without employing bolts or joints of undesirable size.

Further, it is desirable in order to obtain the highest efficiency with the new apparatus that the individual paths for the heating medium should be either equally long or of approximately the same resistance to flow. If concentric coils of tubes are used for the heating surfaces, an approximation to the theoretical efficiency is obtained if the bore of the tubes of the outer set of coils is in a known manner made larger than that of the inner set of coils so as to counterbalance their greater length and heating surface. With equal tube diameters the resistance to flow would be too great in the outer coils and consequently the efficiency of the heating surfaces would be low.

It is also desirable in apparatus constructed of coils of tubes that the individual convolutions should be given such a diameter that they can be screwed one into the other and thereby break up and agitate the steam

flowing past them. If coils of tubes of the same bore are used in apparatus according to the present invention, the total length of the convolutions of the different sets must be approximately equal.

In arrangements heretofore known the individual coils of tubes have been arranged side by side without overlapping, thereby requiring a large amount of space and leaving a large cross-sectional area available for the flow of steam so that the turbulent or whirling action has been small.

According to one type of the present invention the coils of tubes are wound right- and left-handed with a clear space between adjacent convolutions somewhat greater than the outside diameter of the tubes so that the coils can be inserted laterally one into the other, and special supports for the individual convolutions dispensed with.

The use of coils of tubes wound right- and left-handed and inserted laterally one into the other has also the advantage that, in addition to the circular form, any cross-section whatever of the container can be completely filled with coils so that no dead spaces occur.

It is a further advantage of a heat-transmission apparatus according to the present invention that no air or water pockets occur in the tube system through which the heating medium flows.

In the drawings the invention is shown in different forms by way of example.

Figure 1 is a central vertical section of a heat-transmission apparatus with a single group of tube coils screwed one into the other, only the upper and the lower portions of the coils being shown, their intermediate portions being omitted for the sake of clearness; Fig. 2 is a partial vertical section on an enlarged scale, showing the difference in the bore of the coils according to their distance from the center of the apparatus, the bore being shown uniform in Fig. 1, for the sake of convenience; Fig. 3 is a plan view of the lower portion of the apparatus, with the coils omitted; Figs. 4 and 5 are a vertical section and a plan similar to Figs. 1 and 3, respectively, but showing another form of my invention; Fig. 6 is a horizontal section through the central portion of Fig. 4; Figs. 7, 9, 11 and 13 are partial vertical sections illustrating the lower portion of four additional forms of my invention; Figs. 8, 10, 12, and 14 are partly sectional plan views corresponding to Figs. 7, 9, 11 and 13, respectively; Figs. 15 and 16 are a vertical section and a plan similar to Figs. 1 and 3 respectively, but showing a further form of my invention.

Referring to Figures 1 to 3, a tube system, B, is arranged in a container or casing, A, which is closed by two covers, *g*, each provided with a chamber, *f*. Each chamber, *f*, is closed by a plate, *e*, held in its place by screws, *h*, while a rod, *l*, holds the plates, *e*, together so as to facilitate the removal of the tube system, B. This system consists of a number of coils of tubes, *c*, the bore of which increases from the centre towards the periphery or outer wall of the container, A, i. e., the coil of tubes with the smallest bore is arranged in the immediate neighbourhood of the rod, *l*, and that with the largest bore near the outer wall of the container, A. This arrangement is shown diagrammatically in Figure 2. The ends of each of the coils, *c*, are bent towards the rod, *l*, and pass into the plates, *e*, so as to lie within the plane area, X, of the inlet or outlet chamber, *f*. As will be seen from the drawings, the area, X, is considerably smaller than the cross-section of the tube system, B. For the sake of clearness only the upper and the lower portions of the coils *c* have been shown in Fig. 1 (and the same remark will apply to Figs. 4 and 15), the intermediate coil parts, which connect said upper and lower portions, having been omitted. It will therefore be understood that there is a continuous path through each coil from the upper chamber *f* to the lower chamber *f*. On account of the small scale on which Fig. 1 is drawn, the bore of the coils *c* has been shown uniform, but it will be understood that such bore increases from the center or axis (rod *l*) outwardly as illustrated by Fig. 2. The covers, *g*, are provided with branches, *k* and *i*, the latter for the inlet and outlet of the high-pressure heating medium and the former for the inlet and outlet of the steam to be superheated.

The action of the heat-transmission apparatus shown in Figures 1 to 3 is as follows:—

The high-pressure superheating medium, steam or water, enters through the branch, *i*, into the inlet chamber, *f*, in the upper cover, *g*, and from there passes into the coils of tubes, *c*, through the tube ends, *d*, which are secured into corresponding holes in the plate, *e*, by expanding or otherwise. The coils, *c*, are staggered and screwed one into the other and, as will be seen from Figure 1, thus lie close together. The heating medium flows through the individual coils and passes from their lower ends into the outlet chamber, *f*, and so through the outlet branch, *i*. The steam to be superheated passes through the upper branch, *k*, into the container, A, through which it flows and passes out through the branch, *k*, of the lower cover, *g*, to any place desired. In its relatively wide path it passes over and among the individual heating coils at a high velocity and is violently agitated, thereby receiving heat from the tubes in a highly efficient manner.

In consequence of the special bends at the ends of the individual coils of tubes and the

closely packed arrangement of the latter within as small an area, X, as possible of the inlet and outlet chambers, the walls, *e*, can be proportionately thin since bending stresses are reduced to a minimum; the tensile stresses on the screws, *h*, are similarly low and the latter can also be made of comparatively small dimensions. Such reductions of stress are of great importance in view of the fact that pressures up to 150 atmospheres and more have to be considered. It will be noted that the outermost coil or helix, *c*, that is, the helix of greatest diameter, is of smallest axial length, and that the axial length increases as the diameter of the coil or helix, becomes smaller. I thus obtain at the ends of the apparatus, the stepped arrangement shown clearly in Fig. 1, which enables me to avoid sharp bends in the tube ends *d* of even the outermost coil or helix *c*.

It will be seen from the drawings, that in addition the whole tube system can be readily inserted and removed. It will also be noted that the plates *e* to which the tube ends *d* are secured, are much smaller than the covers *g* and are located inside said covers. I thus reduce the weight of the parts connected with said tube ends *d*, and facilitate the assembling and the taking apart of the apparatus.

In Figures 4 to 6 another form of the invention is shown. In this case the whole tube system consists of several groups, *m* and *n* (see Figure 6), four main groups, *m*, being provided while the spaces not occupied by them are filled by smaller groups, *n*. Individual groups consist of a number of coils of tubes which are preferably wound right- and left-handed and inserted laterally one into the other so that the coils afford each other mutual support. In consequence of the arrangement of the groups, *n*, it will be seen that the space within the container, A, is utilized to the best possible advantage. In view of the use of several groups of coils it is necessary to arrange several corresponding inlet and outlet chambers, f^1, f^2, f^3, etc. In the particular example shown, the inlet chambers, f^1, f^2, f^3, etc., are arranged in the side walls of the upper cover, while the branch *k*, for the introduction of the saturated steam is provided on its face or end wall.

In the two forms of apparatus so far described it will be seen that the plate, *e*, is subjected to certain bending stresses, but these can be eliminated either wholly or in part by giving an appropriate shape to the inlet and outlet chambers. As explained above, I give such a shape to the inlet or outlet chamber that the cross-sectional area of said chamber and therefore the area of the plate containing the ends of the tube coils is considerably smaller than the cross-section of the tube system itself.

In Figures 7 to 16 are shown a number of examples of the inlet chambers suitable for the present purpose either as vertical sections or plan views or horizontal sections in the plane X.

In Figures 7 and 8 the chamber, *f*, is spherical, in Figures 9 and 10 cylindrical. Figures 11 and 12 show the inlet chamber as an annular protuberance, and Figures 13 and 14 as a hollow ring. In Figures 15 and 16 the inlet and outlet chambers are arranged in a column "*s*" passing through the container, and are not as in previous examples separated from one another as this form of the invention is intended only for heating with stationary steam which is allowed to condense in situ.

Many other forms of apparatus are possible without exceeding the scope of the invention.

I claim:

1. Heat-exchange apparatus comprising a casing provided with inlet and outlet for one of the media which enter into heat-exchange relation, and also provided with heads recessed on their inner faces to form inlet and outlet chambers, coiled tubing located in said casing and adapted to serve for the passage of the other of said media, and interior members located entirely within the casing and fitted against the recessed portions of said heads to form inner walls for said inlet and outlet chambers, the ends of the tubing being secured to said members and communicating with the interior of said chambers.

2. The structure claimed in claim 1, said inlet and outlet chambers and said interior members having a cross-sectional area smaller than the cross section of the coiled tubing.

3. In a heat-exchange apparatus, a shell, a removable coil system comprising two members adapted to cooperate therewith to form inlet and outlet chambers, and coiled tubing joining and passing through said members, each of said chambers being of smaller cross section than the cross section of the coil of tubing.

4. In a heat-exchange apparatus, a shell, a removable coil system comprising two members adapted to cooperate therewith to form inlet and outlet chambers, coiled tubing joining and passing through said members, each of said chambers being of smaller cross section than the cross section of the coil of tubing, and a rod detachably connecting and holding said members together.

In testimony whereof I have hereunto set my hand.

OTTO HARTMANN.