Feb. 3, 1942. R. M. HARDGROVE 2,271,639

FLUID HEAT EXCHANGE APPARATUS

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Fig. 1

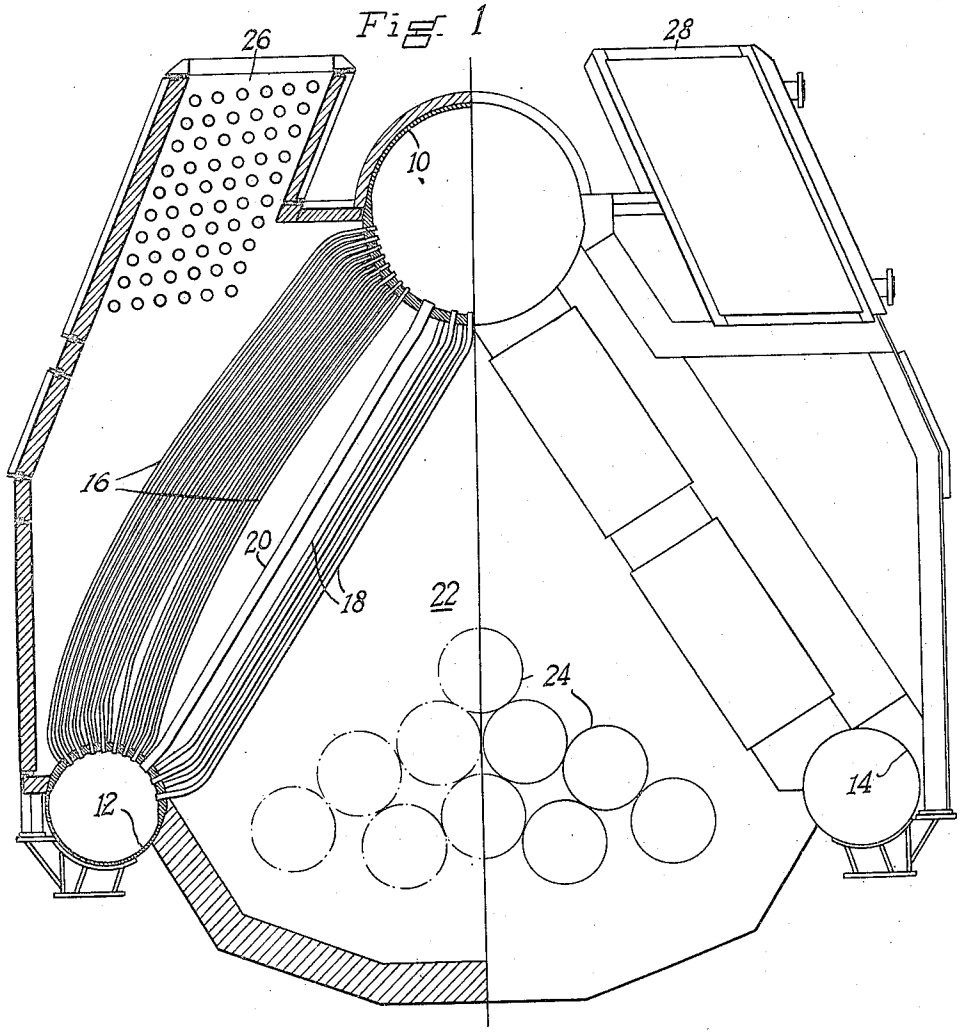
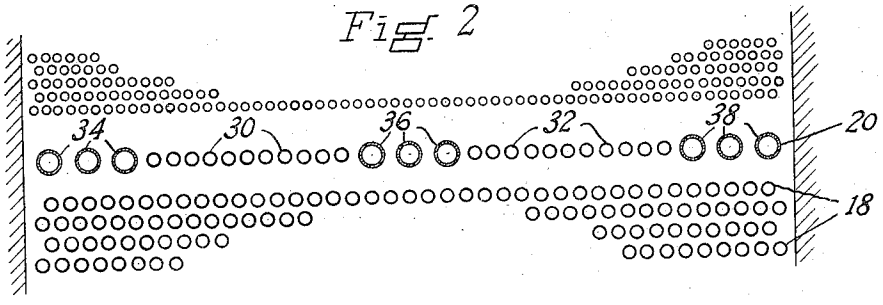


Fig. 2



INVENTOR.

Ralph M. Hardgrove

BY Earl R. Kenyon

ATTORNEY.

Feb. 3, 1942. R. M. HARDGROVE 2,271,639

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Fig. 3

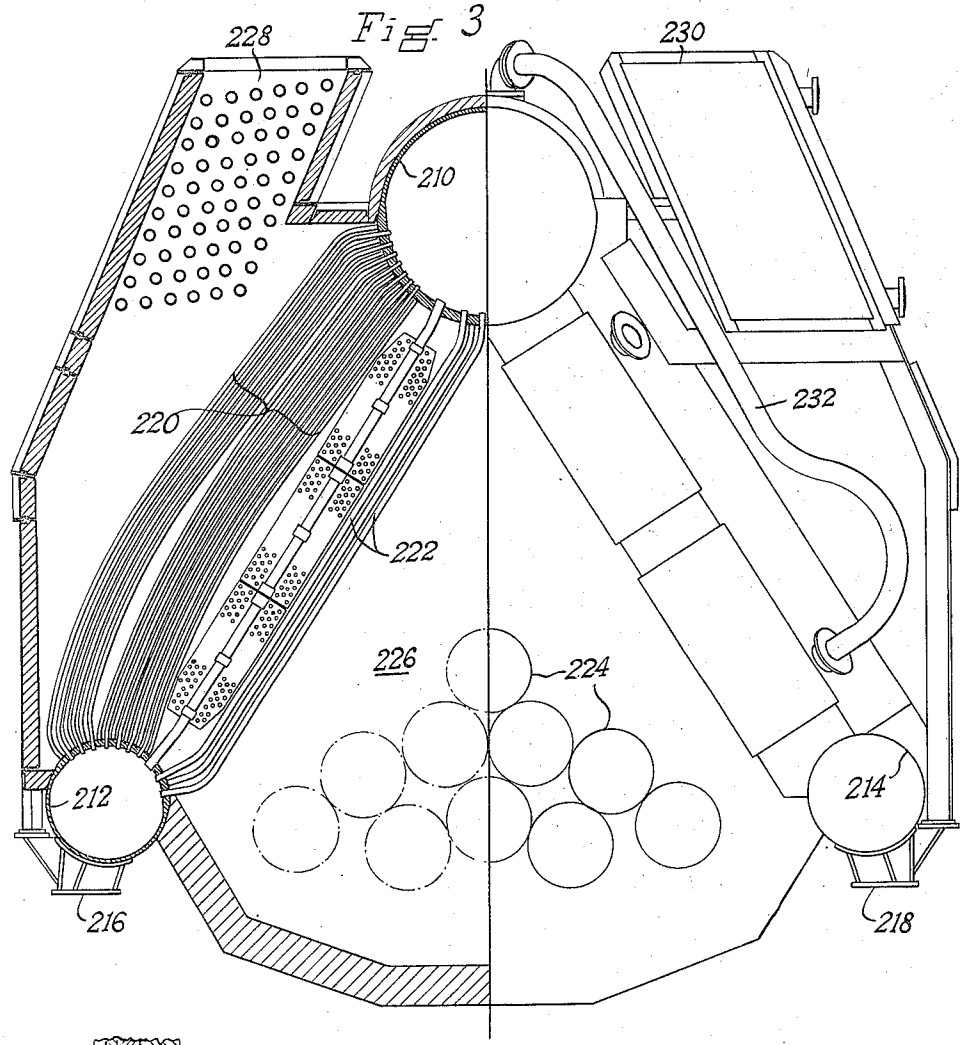
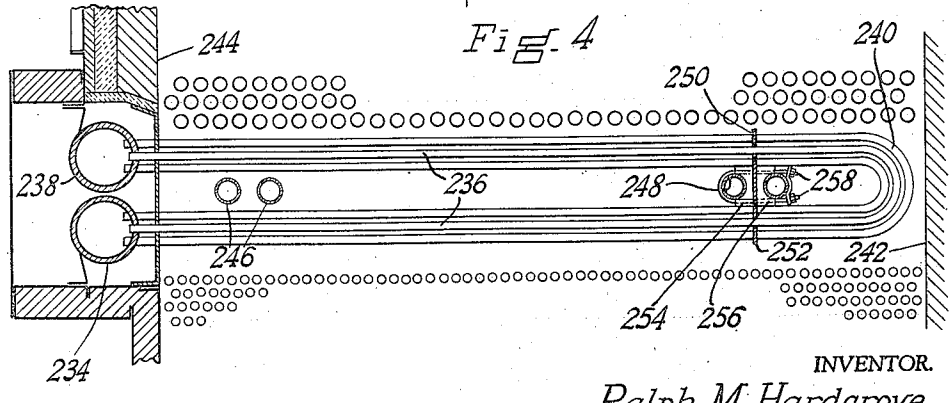


Fig. 4



INVENTOR.

Ralph M. Hardgrove

BY

ATTORNEY.

Feb. 3, 1942. R. M. HARDGROVE 2,271,639

FLUID HEAT EXCHANGE APPARATUS

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Fig. 6

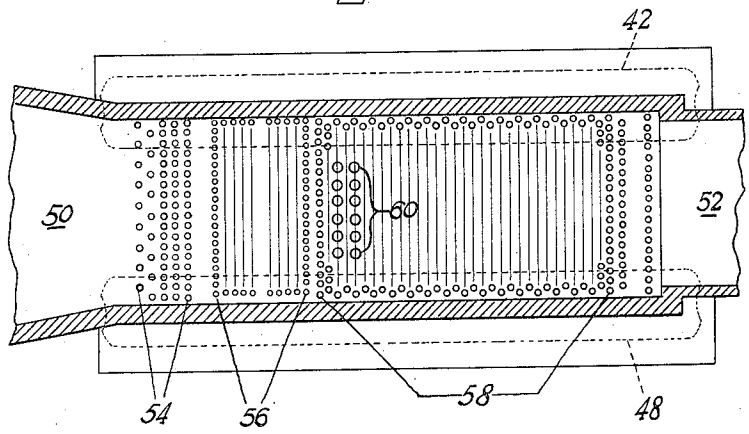
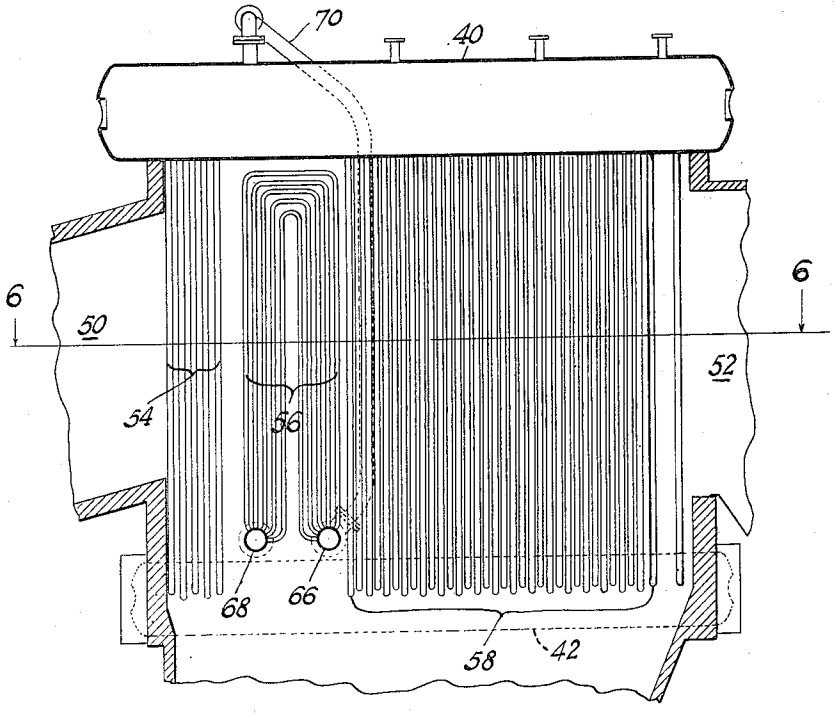


Fig. 5



INVENTOR.

Ralph M. Hardgrove

BY

ATTORNEY.

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FLUID HEAT EXCHANGE APPARATUS

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Fig. 8

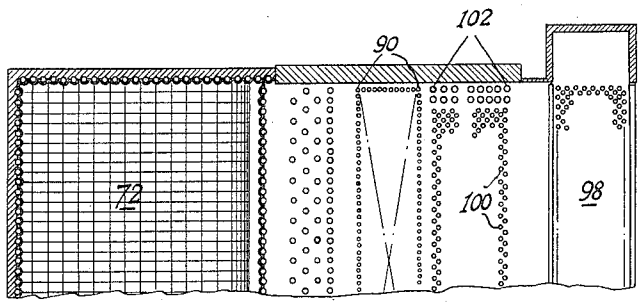
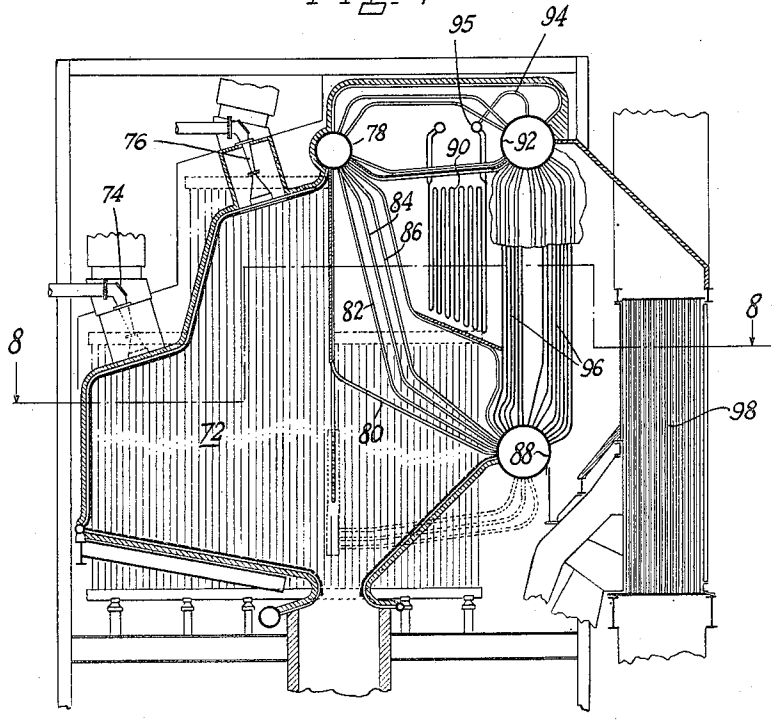


Fig. 7



INVENTOR.

Ralph M. Hardgrove

BY

ATTORNEY.

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FLUID HEAT EXCHANGE APPARATUS

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Fig. 10

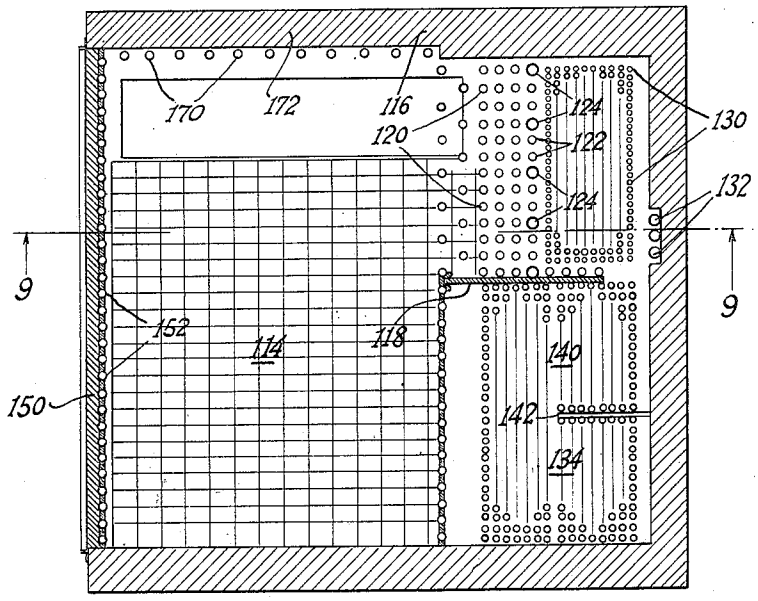
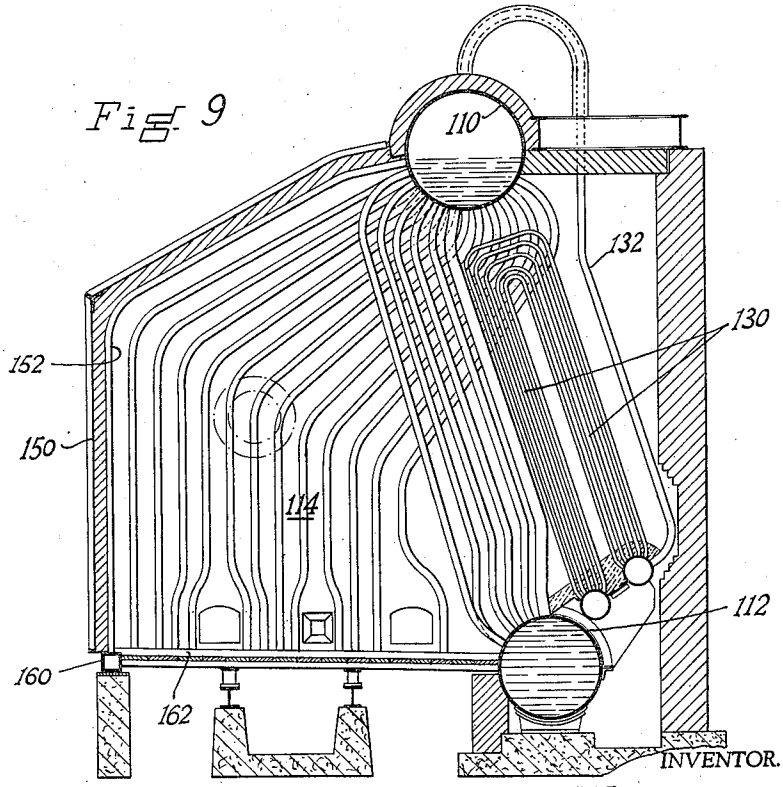


Fig. 9



INVENTOR.
Ralph M. Hardgrove
BY
ATTORNEY.

Feb. 3, 1942. R. M. HARDGROVE 2,271,639

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Fig. 11

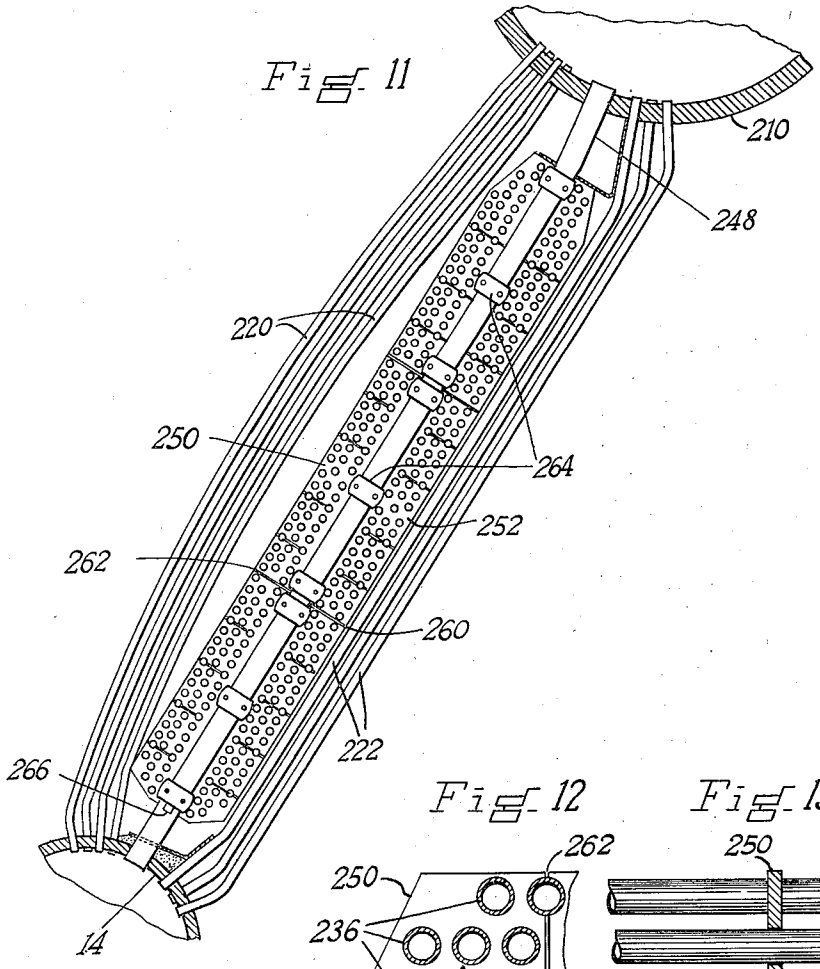


Fig. 12

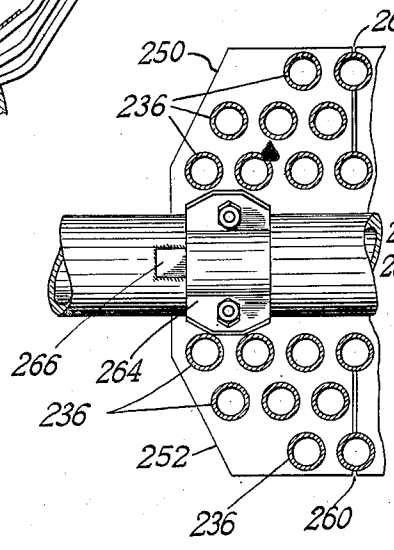
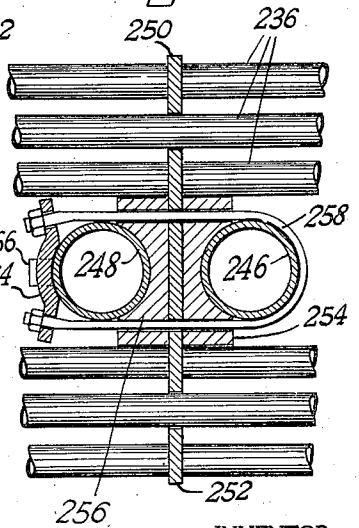


Fig. 13



INVENTOR.

Ralph M. Hardgrove

BY

ATTORNEY.

Patented Feb. 3, 1942 2,271,639

UNITED STATES PATENT OFFICE

2,271,639

FLUID HEAT EXCHANGE APPARATUS

Ralph M. Hardgrove, Westfield, N. J., assignor to The Babcock & Wilcox Company, Newark, N. J., a corporation of New Jersey

Application November 19, 1938, Serial No. 241,387

2 Claims. (Cl. 122—235)

This invention relates to fluid heat exchange apparatus in which there is a natural circulation of fluid through a system of tubes connected to a fluid chamber.

The invention will be considered as exemplified by a water tube steam boiler having a bank of upwardly extending tubes connecting a lower drum to an upper steam and water drum, the flow of water being downward through some of the tubes to the lower drum while steam and water flow upward through other tubes to the steam and water drum. The water is heated by furnace gases sweeping the tubes.

An object of the invention is to prevent damage to the tubes of such apparatus by reason of overheating due to defective circulatory conditions. The invention aims to prevent such damage without the use of external downcomers and without the use of baffles to exclude some of the tubes from contact with furnace gases.

To prevent overheating of the tubes of such boilers a flow of fluid, usually water or a mixture of water and steam, must be maintained through the tubes. When the flow is inadequate stagnation results and the tubes will not be sufficiently cooled internally.

The tubes of water tube boilers of the bent tube type have been usually of the same diameter in order to give manufacturing advantages, and the tendency is for the front tubes of a bank to be risers and the rear tubes downcomers, when furnace gases transversely sweep the tubes from front to rear of the bank. However, there has been no fixed or certain division of the bank of tubes into two sets, and experience has shown that some tubes of such a bank may at one time (and under certain load or firing conditions) be risers, and, at other times and under different conditions, be downcomers, and with this tendency, and circulation uncertainty as to whether the flow in certain tubes be an upflow or downflow, there has been neutralization of flow and circulatory stagnation. This has resulted in the formation of steam pockets, causing the tubes to have high internal resistance to heat transfer. This has resulted in such overheating and consequent tube damage that it has often been necessary to shut boilers down until the damaged tubes could be replaced. Such shut-down periods are particularly undesirable in high capacity steam generating installations operating at high pressures and temperatures.

The higher the steaming capacity of the tube bank, arising from a maximum flow of high temperature furnace gases across it, the more difficult it is to make certain that enough of the tubes will function as downcomers to provide the water required to keep the riser tubes wet at their upper ends and, at the same time, to prevent stagnation in tubes that might be damaged by overheating thereby.

This invention overcomes these difficulties, and, in so doing, involves the use of large diameter tubes subjected to the same furnace gases as adjacent small diameter riser tubes.

The large diameter tubes thus set in a tube bank of tubes of smaller diameter will carry down all the water required by the riser tubes no matter how intensely heated. The boiler circulation is thus stabilized and overheating of tubes prevented.

Another object of the invention is to strengthen the whole structure without costly steel framework when the large diameter downcomers constitute drum supports. The downcomers, being more rigid and stiffer than the smaller tubes of the bank, may be utilized as the major support members for the upper drum from the lower drums. This is especially important in ships. With this arrangement, the smaller tubes may flex as thermal expansion requires, without imposing undesirable limitations of strength requirements and without other supports for the boiler.

In the operation of the above indicated type of boiler there is a flow of water horizontally in the upper drum from regions in which riser tubes discharge steam and water into the drum (or in which separation occurs) to regions where the downcomers conduct water from the drum. Such flows, which may be longitudinally of the drum, impose level differences to maintain them, and such differences are substantial when the distances between those regions are excessive. Thus water level conditions become unstable and good boiler operation difficult. The present invention overcomes this difficulty by such disposition of the large diameter tubes that the paths of such flows are as short as possible. The characteristic whereby the downcomers may be subjected to the same high temperature gases as the risers without impairing the downward flow in them permits this result to be achieved.

An additional object of the invention is to support a superheater in such boilers, especially those typical of marine practice in which small diameter water tubes are used in the bank, and which might be unduly stressed if the weight of the superheater were borne by them, and with least possible and perhaps no external supports

for the superheater. In marine boilers of this class, it is the practice to locate the superheater in front of the main tube bank and behind rows of tubes forming a water screen in a position where the gases are of high temperature and there must be supports for the superheater. If these supports are located externally of the gas pass to avoid overheating of the supports, additional weight and expense is incurred. When large diameter tubes are located intermediate of first and last rows of tubes between the drums, they may be used as water cooled supports for the superheater and thus the superheater is supported independently of the tubes of the bank and screen, being kept cool by the downcomer flow of water in them. No other superheater support is necessary, but in some cases the external headers may be used to support the superheater in part while the large downcomer tubes provide the rest.

Other objects of the invention will appear as the accompanying description proceeds, the invention being described with reference to the drawings which indicate preferred embodiments of the invention.

In the drawings:

Fig. 1 is partly a vertical section and partly an elevation of a steam generator constructed in accordance with this invention;

Fig. 2 is a transverse horizontal section through a bank of tubes such as that shown in Fig. 1 of the drawings;

Fig. 3 is a view similar to Fig. 1, showing a somewhat modified steam generator;

Fig. 4 is a transverse section through the superheater and the bank of tubes of the Fig. 3 generator;

Fig. 5 is a view somewhat in the nature of a vertical section through a steam generator which constitutes an additional embodiment of the invention;

Fig. 6 is a horizontal section taken on the line 6—6 of Fig. 5;

Fig. 7 is a vertical section through a bent tube boiler in which the teachings of this invention are utilized;

Fig. 8 is a partial transverse section on the broken section line 8—8 of Fig. 7;

Fig. 9 is a vertical section indicating another type of steam generator, this view being taken on the section line 9—9 of Fig. 10;

Fig. 10 is a plan of the steam generator indicated in Fig. 9;

Fig. 11 is an enlarged detail view of a part of the superheater construction of the Fig. 3 boiler; and

Figs. 12 and 13 are detail views of parts of the boiler shown in Figs. 3, 4 and 11.

The steam generator shown in Fig. 1 of the drawings includes the steam and water drum 10 connected by downwardly diverging banks of tubes to the water drums 12 and 14. The drum 12 is directly connected to the drum 10 by a bank of tubes 16, rows of tubes 18, and a middle group of tubes 20, the tubes 18 comprising a furnace screen or narrow front bank. On the opposite side of the furnace 22 the drum 14 may be connected to the drum 10 by similar groups of tubes.

The furnace 22 is fired at high rates by a plurality of burners 24, and furnace gases sweep transversely of the tubes extending upward to the drum 10, and then pass to the separate outlets 26 and 28.

The arrangement of tubes on either side of the furnace 22 may be somewhat as indicated in Fig. 2 of the drawings. The tubes of the screen 18 are steam generating tubes, or risers, discharging steam and water into the drum 10. Likewise, the tubes 30 and 32 of the middle group 20 are risers, but adjacent the latter in the same row and distributed in three groups across the gas pass are the large diameter tubes 34, 36, and 38 which act definitely as downcomers. They are distributed across the width of the gas flow and the length of the drum so as to make the horizontal flow of water within the drum short and to afford adequate structural support for the drum 10 from the drums 12 and 14 which are carried on saddles as shown. These larger tubes 34, 36, and 38 are subject to furnace gases which are of the same temperature as the gases which contact with the tubes 30 and 32 in the same row, but by reason of the considerably larger diameter of the tubes 34, 36, and 38 they act to conduct water downwardly from the drum 10 to the drum 12 even when the smaller tubes in the same zone are acting as risers.

The steam generator indicated in Figs. 5 and 6 of the drawings includes a single upper steam and water drum 40 connected by upright tubes to two lower water drums 42 and 48. The latter are disposed toward the opposite sides of the horizontal gas pass in which the main portions of the tubes are located. Hot gases pass from the inlet 50 across the upright tubes and then to the gas outlet 52. As shown, there is a front bank of steam generating tubes 54, a superheater 56, and a rear bank of tubes 58. The latter are all of the same diameter except for the tubes of the group 60. This group is shown as consisting of twelve tubes of much greater diameter than the adjacent tubes of the bank 58 so that they will definitely act as downcomers. The latter tubes are symmetrically arranged so that they may be expanded into the upper drum 40 at their upper ends while half of them are expanded into the drum 42 at the lower part of the boiler. The remainder of these tubes are expanded into the other lower drum 48.

The superheater 56 consists of U-tubes communicating with a superheater inlet header 66 and an outlet header 68 located below the level of the flowing hot gases. The former is directly connected with the steam space of the drum 40 by a conduit 70.

The steam generator indicated in Figs. 7 and 8 of the drawings includes a furnace 72 fired by burners 74 and 76 and having its walls defined by water tubes connected into the boiler circulation, some of these tubes being directly connected to the upper drum 78. From the furnace the combustion gases pass across a screen formed by the spaced tubes 80, 82, 84, and 86. These tubes are shown as directly connecting the submerged drum 88 with the upper drum 78.

After passing across the tubes 86 the furnace gases from the furnace 72 contact with the tubes of the superheater 90 which are suspended in the path of the furnace gases. The superheater receives steam from the steam and water drum 92 through the saturated steam supply tubes 94 and the superheater inlet header 95.

After passing across the superheater the gases in the Fig. 7 boiler pass across the tubes of the rear bank 96 and thence through the air heater 98 to a flue. The furnace gases are at such high temperatures in contacting the tubes of the bank 96 that some of the tubes 100 of that bank act as steam generators or risers. However, the bank of tubes 96 includes groups of downcomer tubes some of which are shown at 102. These tubes

are of much larger diameter than the risers 120 and may be arranged in groups located at spaced positions in the bank 96, and longitudinally of the drums 88 and 92.

The steam generator indicated in Figs. 9 and 10 of the drawings includes a steam and water drum 110 connected by upright tubes to a submerged drum 112. Hot gases from the furnace 114 pass through an outlet between the boiler setting wall 116 and the baffle 118. Across this gas flow path there are arranged five rows of relatively small diameter steam generating tubes 120. The sixth row of tubes located at the rear of these five rows includes the risers 122 which are preferably of the same diameter as the tubes in the first five rows and are arranged in groups of two. Between these successive groups there are large diameter tubes 124 which, though exposed to the furnace gases at the same temperature as the gases contacting the risers 122, act as downcomers. It will also be noted that the tubes 124 are distributed uniformly across the bank of steam generating tubes between the wall 116 and the baffle 118 so that the water flow within the drum 110 from the tops of the risers to the tops of the downcomers is shorter than it otherwise would be.

In the modification shown in Figs. 9 and 10 and positioned rearwardly of the above described steam generating tubes is a superheater 130 receiving steam through the conduit 132 from the steam and water drum 110. Beyond the superheater the gases turn around the rear edge of the baffle 118 and pass across tubes arranged within the second gas pass 140. They make one more turn in moving from this gas pass around the forward edge of the baffle 142 and then sweep transversely of the tubes of the gas pass 134, and move to a flue.

The wall 150 of the furnace indicated in Figs. 9 and 10 is defined by wall tubes 152 which are connected into the boiler circulation by reason of their communication with the drum 110, the header 160, the floor tubes 162, and the drum 112. Other wall tubes 170 extend along the wall 172 from a lower header to the drum 110.

Fig. 3 of the drawings illustrates a marine boiler in which a steam and water drum 210 is connected with the lower drums 212 and 214 by banks of tubes. The drums 212 and 214 are bottom supported upon saddles or pedestals 216 and 218 and the drum 210 is supported from the drums 212 and 214 through some of the tubes which connect those drums. A bank of tubes 220 and screen tubes 222 are shown connecting the drum 210 to the drum 212, and it will be understood that a similar arrangement of tubes connects the drum 214 with the drum 210.

A furnace 226 is located between the upwardly converging screen rows and banks of steam generating tubes and its burners 224 are preferably disposed in a furnace wall which is normal to the longitudinal axes of the drums. When a comparatively large number of burners is used, and supplied with a fuel oil, the furnace is fired at high ratings, and high steam generating capacities are attained. The furnace gases pass from the combustion chamber 226 across the steam generating tubes to outlet flues 228 and 230. Such auxiliaries as economizers and air heaters may be disposed in these flues and the operation of the apparatus may be controlled by dampers positioned in the flues. Saturated steam passes from the drum 210 through an offtake conduit 232 to a superheater inlet header 234. This header is shown disposed alongside the boiler setting and in parallelism with the tubes of the bank 222.

As indicated in Fig. 4 of the drawings the header 234 is connected by relatively small diameter superheater tubes 236 to an outlet header 238. The latter is shown as positioned alongside the inlet header 234 and arranged in parallelism therewith. From the outlet header 238 the superheated steam passes to a point of use.

As further indicated in Fig. 4 of the drawings the superheater tubes are in the form of loops. Each tube presenting a loop 240 near the wall 242 of the boiler. At the opposite wall 244, the superheater tubes are supported by the headers 234 and 238, and the looped ends of the superheater tubes are supported by water tubes 246 and 248 of relatively large diameter. The latter are shown arranged in groups of two near the opposite sides of the tube banks. These large diameter tubes are in communication with the upper and lower drums, and although they are exposed to furnace gases at higher temperatures than the gases contacting with the tubes of the bank 220, they definitely act as downcomers on account of their increased diameter. These tubes are arranged transversely of the rows of superheater tubes as shown, and between the tubes 248 there are clamped metallic plates 250 and 252, together with the metallic saddles 254 and 256, shown in better detail in Fig. 13 of the drawings. They are held in compact relationship by the clamping devices 258. This entire assembly constitutes an inclined water cooled beam or column independent of the other tubes of the boiler and disposed across the gas pass as an heat absorber.

The plate members 250 and 252 are parallel to the water tube beam and are protected from overheating by the good thermal connection made by the clamping members and the interposed saddles 254 and 256. The circulation of water through the beam or column keeps the metal temperature of its parts at properly low values. Excessive distortion of the plates 250 and 252 due to differences of temperature at the edges of the plates is prevented by slots 260 and 262 which are shown in Fig. 12 of the drawings as extending inwardly from the edges of the plates remote from the tubes 246 and 248.

The clamp members 264 and their associated parts are maintained at desired elevations along the tubes 248 by lugs 266 which are welded to those tubes. Thus the vertical gravitational load of the superheater is taken at one end by the tubes 248 at a plurality of positions along those tubes, dependent upon the positioning of the lugs 266. A similar support for the other end of the superheater loops may be provided by the tubes 246.

This application is a continuation in part of applicant's co-pending application, Serial No. 38,345, which has eventuated into Patent No. 2,165,258, dated July 11, 1939.

I claim:

1. In fluid heat exchange apparatus, an upper drum, a lower drum, a bank of fluid conducting tubes forming risers connecting the drums and swept transversely by furnace gases, said risers being arranged in rows transversely of the gas stream, and a plurality of other fluid conducting tubes arranged in at least one of said rows and providing downcomers each of which is of an inside diameter at least 50% greater than that of the risers and of uniform flow area throughout

its length, said downcomers joining said drums and being disposed intermediately of said bank (front to rear) and being swept by the furnace gases in a manner similar to the risers.

2. In fluid heat exchange apparatus, an upper drum, a lower drum, a bank of fluid conducting tubes forming risers connecting the drums and swept transversely by furnace gases, said risers being arranged in rows transversely of the gas stream, and a plurality of other fluid conducting tubes providing downcomers each of which is of an inside diameter at least 50% greater than that of the risers and of uniform flow area throughout its length, said downcomers joining said drums and being disposed intermediately of said bank (front to rear) and being swept by the furnace gases in a manner similar to the risers.

RALPH M. HARDGROVE.