

Feb. 4, 1947.

J. D. ANDREW, JR

2,415,068

TUBE SPACER AND SUPPORT

Filed July 13, 1943

2 Sheets-Sheet 1

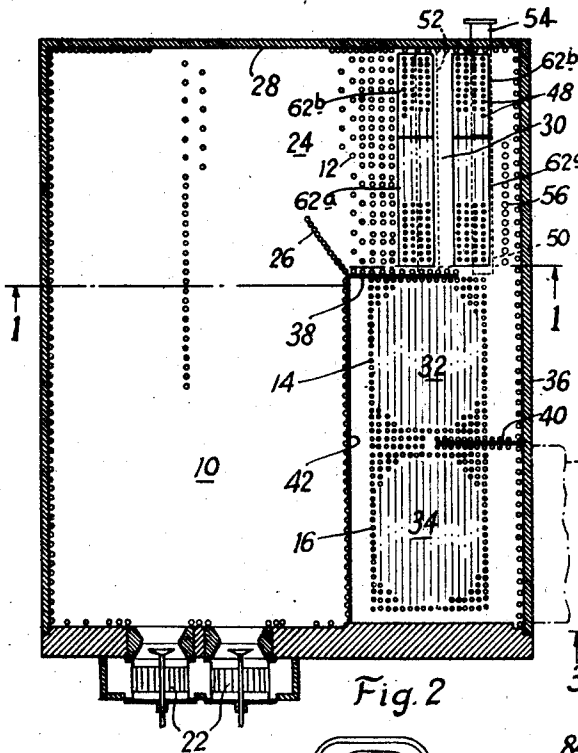


Fig. 2

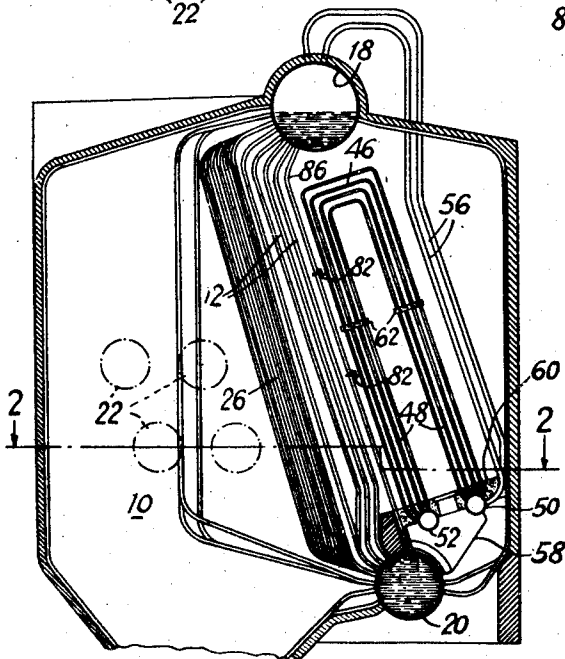


Fig. 1

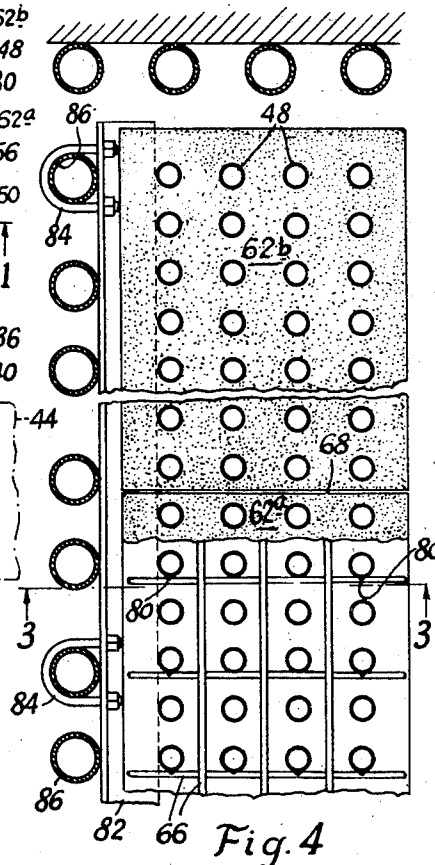


Fig. 4

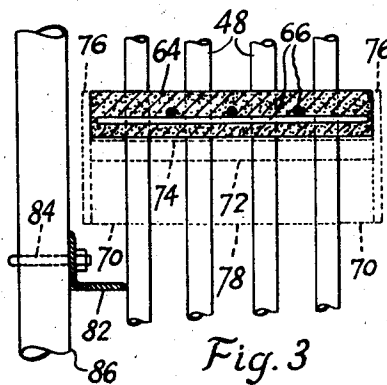


Fig. 3

INVENTOR.

James D. Andrew, Jr.

BY

J. P. Moran

ATTORNEY

Feb. 4, 1947.

J. D. ANDREW, JR

2,415,068

TUBE SPACER AND SUPPORT

Filed July 13, 1943

2 Sheets-Sheet 2

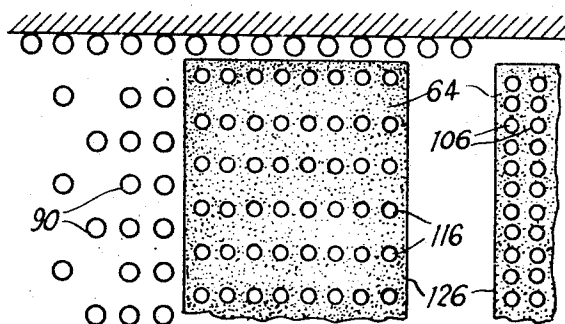


Fig. 6

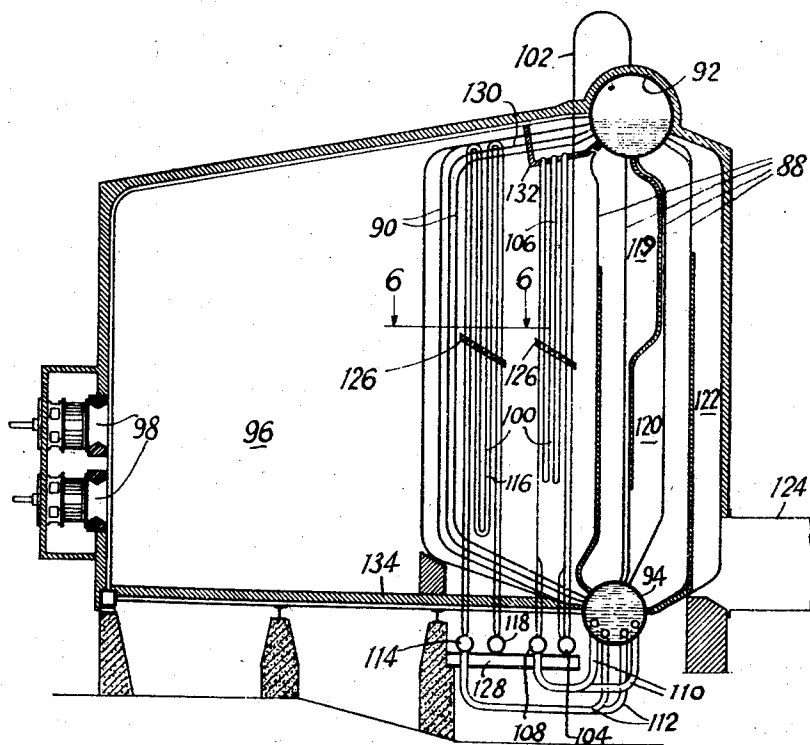


Fig. 5

INVENTOR.

James D. Andrew, Jr.

BY

J. S. Moran

ATTORNEY

UNITED STATES PATENT OFFICE

2,415,068

TUBE SPACER AND SUPPORT

James D. Andrew, Jr., Essex Fells, N. J., assignor
to The Babcock & Wilcox Company, Rock-
leigh, N. J., a corporation of New Jersey

Application July 13, 1943, Serial No. 494,584

13 Claims. (Cl. 122-478)

1

The invention herein disclosed relates to a tube spacer construction for maintaining the tubes of a bank of tubes in predetermined spaced relation transversely of their lengths. The invention is applicable to the fluid carrying tubes of heat exchangers generally but is especially advantageous when applied to the tubes of a heat exchanger wherein relatively long lengths of tubes are arranged upright and are swept by heating gases of relatively high temperatures.

It is known that in convection heated apparatus of the character herein described the spacing of the tubes transversely of their lengths has an important bearing on the rate of heat transfer and, with other conditions remaining constant, a closer spacing of the tubes results in a higher rate of heat transfer. When tube spacings are made small, any variation in the spacing between individual tubes of the bank alters the area available for gas flow between tubes, and because of the normally close spacing the change in gas flow area is a high percentage of the intended area, and the resulting gas mass flow becomes appreciably higher or lower depending on the direction of change.

Such displacements of the tubes may result from overheating of the tube metal causing distortion due to the high temperatures of the heating gases in relation to temperatures of the fluid within the tubes. Since the tubes of themselves are unable to resist this tendency to become distorted, it has been customary to employ spacer elements of one description or another in an attempt to maintain the spacings at their intended normal values, but such means as heretofore used have been inadequate in that they do not provide a sufficiently rigid lateral support to the tubes in every direction, nor do they afford an especially durable separator means capable of withstanding the high temperatures of the heating gases over reasonably long periods before requiring replacement.

Spacer elements for the tubes of superheaters, for example, have usually been made of metal, and because of the high temperatures involved, such elements have been formed of various alloys whose compositions for the most part require metals which are not only expensive, but which under present priority conditions are not readily available in the quantities necessary.

It is therefore an object of my invention to provide a spacer means for closely spaced upright tubes which by reason of its rigidity will serve to support the tubes laterally in every direction in a given transverse plane.

It is proposed that such a spacer means is to be so arranged that its weight is sustained solely by the tubes which it supports whereby it is free to move with said tubes in relation to other structures extraneous to said tubes.

2

In accordance with this invention it is also an object to utilize a material or materials sufficiently resistant to the temperatures to be encountered as to afford a construction relatively permanent in character.

An additional object is to provide a spacer support capable of being manufactured and installed simultaneously, thereby contributing to savings in labor and expense, and by forming an essentially monolithic structure enabling a predetermined spacing of the tubes to be maintained.

The foregoing objects and advantages, as well as others will be more fully understood from the description to follow, particularly when read in conjunction with the accompanying drawings, in which:

Fig. 1 is a sectional side elevation of a boiler unit illustrating an embodiment of my invention as applied to the superheater thereof;

Fig. 2 is a sectional plan of the boiler unit shown in Fig. 1, taken along line 2-2;

Fig. 3 is a fragmentary enlargement of parts shown in Fig. 1;

Fig. 4 is a plan view, partly broken away, of parts shown in Fig. 3;

Fig. 5 is a sectional side elevation of a boiler unit showing an application of my invention in modified form, and

Fig. 6 is an enlarged fragmentary plan section of parts shown in Fig. 5.

In detail and referring particularly to Figs. 1 and 2, the boiler unit as shown is of the integral-furnace type wherein the boiler furnace or combustion chamber 10 is located to one side of the boiler heating surface comprising groups of upright boiler tubes 12, 14 and 16 which are connected to the upper and lower boiler drums 18 and 20. The disposition of boiler heating surface in relation to the boiler furnace is generally similar to the arrangement disclosed in U. S. Patent to E. G. Bailey et al. 1,999,984, granted April 30, 1935. The furnace is suitably fired from one end as indicated in Fig. 2, utilizing burners 22 of a type selected for the character of fuel or fuels to be burned.

The hot gases of combustion are discharged from the furnace chamber through the gas outlet 24 provided between one end of the inclined deflector baffle 26 and the adjacent wall 28 of the setting, the gases being directed over the groups of boiler tubes 12, 14 and 16 through a plurality of transverse heating gas passes 30, 32 and 34 arranged in a horizontal series adjacent the side wall 36 of the setting, such passes being principally defined by the transverse baffle walls 38 and 40, and the longitudinal baffle wall 42, in combination with adjacent walls of the setting. The spent heating gases leave the setting through

3

the gas outlet 44 conveniently located at the bottom of the final gas pass 34.

In their course through the first gas pass 30 the hot gases of combustion are directed over the tubes of a superheater 46 wherein the superheater tubes 48 are formed as U-shaped loops and are arranged upright with the closed ends of the loops uppermost. A section transversely of the superheater tube bank, as illustrated in Fig. 2, shows the tube lengths as being arranged in bundles and being spaced apart in successive rows extending transversely of the direction of gas flow and, in addition, in successive rows paralleling the direction of gas flow. The superheater tubes have their ends connected to bottom headers 50, 52 and 54, one group of tubes connecting the inlet header 50 with an intermediate header 52, and the remaining group of tubes connecting the intermediate header 52 with the outlet header 54, thereby causing steam to pass through the two groups of superheater tubes in succession. The inlet and outlet headers 50 and 54 may be made separate, or may be formed as separate sections of the same header, the saturated steam being conducted to the inlet header or section 50 through connections 56 leading from the upper steam and water drum 18. The headers 50, 52, 54 are cradled in longitudinally spaced cantilever beams 58 which are fixed to the lower boiler drum 20 thereby supporting the superheater entirely from below. A layer of refractory 60 above the headers serves as a protection for the superheater tube connections and the header supports 58.

The preferred means for maintaining the superheater tubes 48 in a predetermined spaced relation is essentially monolithic and formed as a plate or slab 62 extending transversely of the tubes 48 of each leg of the superheater bank at a location somewhat more than one half the height of the loop tubes 48 above the headers 50, 52 and 54. As shown in detail in the enlarged views Figs. 3 and 4, each plate 62 is a rigid self-sustaining structure, being formed of a hardened plastic material 64 highly refractory to the heat of combustion gases, and to erosion by such gases, and if desired including metal wires or rods 66 embedded therein for reinforcement. Each plate 62 for each leg of the tube bank is preferably divided at 68 into separate sections 62a and 62b thus providing a separate section for each leg for each pass of the steam through the superheater, a section 62a being provided for each leg of tubes conducting steam at a relatively low temperature from the saturated steam inlet header 50 to the intermediate header 52, and a section 62b being provided for each leg of tubes conducting steam at a higher temperature from intermediate header 52 to the superheated steam outlet header 54.

The installation of the tube spacer 62 is facilitated by constructing a temporary form about the tubes 48 at the desired location, as indicated by dotted lines in Fig. 3. Such a form, of wood for example, may consist of a pair of beam members 70 extending across the direction of gas flow, with a layer of slats 72 laid across the beams, and a layer of thin strips 74 laid across the slats, the slats 72 and strips 74 being laid in intersecting directions and practically closing off the spaces between the tubes 48, the side and end boards 76 and 78 completing the temporary structure.

The wires or rods 66 may then be placed between the tubes at the desired intervals, either

4

directly on the layer of strips 74, or at some higher level intermediate the intended thickness of the finished plate as shown. Some or all of the wires may be welded to certain tubes of the bank as indicated at 80 as a means of resisting any tendency for the completed spacer to shift along the tubes.

It is desirable to make certain that the tubes 48 are properly spaced and in alignment before placing the material 64 within the form, and preferably to provide some temporary spacer means (not shown) designed to remain in place until the material 64 has fully hardened. The material 64 in its initially fluid or plastic state is poured or rammed into the form or mold which has been provided, to completely fill the spaces between and around the tubes 48 and, being somewhat cementitious in character, will upon hardening form a solid substantially monolithic and self-sustaining structure capable of maintaining its shape under all service conditions, the hardened material conforming closely to the contours of the tubes, and adhering to a degree to their surfaces, to preserve the intended tube spacing and alignment. The material 64 may be any one of a variety of commercially available materials such as heat resisting plastics and mortars commonly used in furnace construction and repairs, and in certain instances in the construction of gas directing boiler baffles. A suitable material for the purpose is known as "B&W Baffle Mix, Type A or Type B," a product of The Babcock & Wilcox Company, 85 Liberty Street, New York, New York. Such a material sets without the application of heat and retains its hardness and strength up to its limiting temperature of 2600° F., in addition to having low expansion and shrinkage values and providing adequate resistance to abrasion.

In view of the inclination of the tubes 48, the tendency for the tube bank to rotate about its lower support 58 is opposed by angles 82 secured as by U-bolts 84 to adjacent boiler tubes 86.

It has been found that a single plate 62 for each leg of the superheater tube bank 46 is adequate for maintaining tube spacing and alignment where previously a plurality of metallic spacers had been required. The monolithic type of spacer provides a substantially permanently rigid assembly whereas with the metallic spacers formerly employed, a multiplicity of parts was required, involving numerous separate assemblies, and resulting in an overall assembly of the bank which was subject to distortion of its shape in service and consequent misalignment and variation in spacings of the tubes. Moreover, the monolithic type of spacer 62 is in itself highly refractory to the hot combustion gases independent of any cooling effect due to its thermal engagement with the tube walls. In the case of metallic spacers, the original thermal contact with the tubes is generally incomplete and ordinarily cannot be maintained, so that regardless of the metal employed, whether cast iron or a temperature resistant alloy, the spacers are apt to be burned away with a resulting variation in tube spacings and an impairment in the rate of heat transfer.

In the modification according to Figs. 5 and 6, the boiler unit is of a type wherein the major portion of the boiler heating surface comprises banks of tubes 88 and 90 connected to upper and lower boiler drums 92 and 94 and laterally adjoining a boiler furnace or combustion chamber

5

96 fired by burners 98 suitable for the fuel or fuels to be burned.

A superheater 100 is positioned between the banks of boiler tubes 88 and 90, being screened in part from the radiant heat of the combustion chamber by the bank of boiler tubes 90. Saturated steam is conducted from the upper boiler drum 92 by means of tubes 102 to the inlet superheater header 104 from which it passes through vertically extending tubes 106 of a first section of the superheater to an intermediate header 108; thence through connections 110 to a desuperheater unit (not shown) within the lower drum 94; thence through connections 112 to an intermediate header 114; and then through vertically extending tubes 116 of a second superheater section to the superheater outlet header 118.

The hot gases of combustion leaving the furnace chamber 96 sweep across the entire exposed lengths of boiler tubes 90 and immediately thereafter engage the banks of superheater tubes 106 and 106 in succession, whereupon the flow of gases is continued throughout the boiler bank 88 in a plurality of longitudinal passes 119, 120 and 122 to the gas outlet 124.

A monolithic form of spacer plate 126 is employed for each of the banks or bundles of superheater tubes 106 and 116, similar in construction and material to the spacer means 62, and for this reason such details need not be repeated. Similarly, the spacer 126 is installed transversely of the superheater tubes, although in this instance the spacers are slightly inclined to the lengths of the tubes 106 and 116 and therefore inclined to the horizontal so that in the particular arrangement shown, the spacer plates tend to deflect a portion of the heating gases downwardly and thus improve distribution of the gases over the entire superheater heating surface.

The entire weight of the superheater 100 is preferably supported entirely from below as in the previously described embodiment, thereby obviating the use of the usual overhead metallic suspension members which because of the temperature zone in which located would require the use of heat resistant alloys difficult to obtain, the weight of the superheater being carried by a plurality of suitably supported transverse beams 128 on which rest the superheater headers 104, 108, 114 and 118.

The tubes 106 and 116 of both superheater sections are in multiple loop formation, so that each tube 106 or 116 provides a plurality of passes across the flow of heating gases. As seen in Fig. 6, the spacing of tubes 106 in rows extending longitudinally of the upper drum 18 is one-half the spacing of the superheater tubes 116, and of the boiler screen tubes 90, in similarly arranged rows. All of the superheater tubes 116 may therefore be extended upwardly to a level where their upper loop ends are between the horizontally extending portions 130 of the boiler screen tubes 90 which thus serve to prevent excessive relative movement laterally between the tubes 116 at their ends. Due to the closer spacing of tubes 106 in the other section of the superheater, only half of these could be conveniently extended upwardly into the spaces between the horizontal boiler tube portions 130, and consequently, in preference, a monolithic baffle structure 132 is provided adjacent the roof of the setting, and the upper loop ends of tubes 106 extended into the lower wall thereof, desirably

6

through individual openings therein, whereby excessive relative movement of such tube ends is similarly prevented. The guiding of tubes 106 and 116 at their upper loop ends, as described, permits expansion and contraction of the bottom-supported tube lengths with minimum distortion, and in conjunction with the rigid monolithic spacer 126 at an intermediate location, enables longer tube loops to be used than if the upper loop ends were left entirely free and unrestricted as to relative lateral movement. For example, but without indicating specific limitations of the invention, in the form of Fig. 1 where the upper loop ends are left free, the height of the loops above the layer of refractory 60 is approximately one hundred three times the diameter of the tubes, whereas in the form of Fig. 5 where the upper tube ends are guided, the height of the loops above the floor 134 of the setting may be approximately one hundred twenty-nine times the diameter of the tubes, the increase in ratio of loop length to tube diameter thus being approximately twenty-five per cent.

The invention as herein disclosed in accordance with the provisions of the statutes will be understood by persons skilled in the art to be applicable in arrangements other than those specifically described, and to include features which may be used to advantage without a corresponding use of other features, within the scope of the appended claims.

I claim:

1. In combination with a bundle of closely spaced superheater tubes arranged upright for transverse flow of heating gases thereover in a single gas flow heating pass, said tubes being arranged in rows paralleling said heating gas flow with several of said tubes in each of said rows, a header at the lower ends of said tubes to which said tubes are connected for sustaining the weight of said tubes and for maintaining the lowermost extremities of individual tubes in spaced relation transversely of said bundle, means for maintaining said tubes in predetermined spaced relation throughout other portions of their lengths comprising a slab of hardened plastic heat resistant material installed between and around said tubes transversely of said bundle at a location intermediate the height of said bundle, and means associated with said slab and cooperating solely with said tubes for maintaining said spacer slab substantially fixed in position longitudinally of said tubes.

2. In combination with serially connected bundles of superheater tubes adapted to be contacted successively by heating gases flowing transversely thereover, the tube lengths throughout each bundle being arranged upright and being spaced apart both in the direction of gas flow and in a direction transversely thereto, said tube lengths being arranged in rows paralleling said heating gas flow with several of said tube lengths in each of said rows, means for supporting the weight of said tubes entirely from below, and plate-like members predominantly monolithic and non-metallic each extending across the tube lengths of one of said bundles for separately supporting the tube lengths of each bundle laterally to maintain predetermined spacings between tube lengths in said bundles, each said spacing and supporting member engaging only the tube lengths of one of said bundles and being sustained solely thereby.

3. In combination with a bank of inverted U-shaped superheater tubes having the major por-

tions of their lengths straight and forming serially connected spaced bundles of tube lengths adapted to be contacted successively by heating gases flowing transversely thereof, headers to which the lower ends of said tubes are connected, means for supporting said headers and thereby the entire weight of said superheater tubes, and monolithic means disposed transversely of at least said bundle first contacted by said gases for rigidly supporting the tube lengths of said bundle against lateral displacement, whereby the spacing between the tube lengths of said bundle is maintained constant, said monolithic spacer and supporting means engaging only the tube lengths of said bundle and having its weight supported wholly thereby, said bundle comprising tube lengths arranged in a plurality of rows paralleling the flow of said gases with a plurality of tube lengths disposed in each of said rows.

4. In combination with a bank of inverted U-shaped superheater tubes having the major portions of their lengths straight and forming serially connected spaced bundles of tube lengths adapted to be contacted successively by heating gases flowing transversely thereof, each bundle comprising tube lengths arranged in a plurality of rows paralleling the flow of said gases with a plurality of tube lengths disposed in each of said rows, headers to which the lower ends of said tubes are connected, means for supporting said headers and thereby the entire weight of said superheated tubes, and monolithic members each disposed transversely of one of said bundles for rigidly supporting the tube lengths of each bundle separately against lateral displacement, whereby the spacing between tube lengths in a given bundle is maintained constant without interfering with the movement of one bundle relative to another, each said monolithic spacer and supporting member for each bundle having its weight supported wholly by the bundle of tubes engaged thereby.

5. In combination, a bank of upwardly extending superheater tubes adapted to be swept by heating gases flowing transversely thereover to a gas outlet adjacent the upper portion of said bank, said tubes including vertically extending straight length portions connected at their ends by return bends to form a succession of continuous tube lengths in looped formation each paralleling the direction of heating gas flow, headers below the level of said bank to which the ends of said looped tube lengths are connected, means for supporting said headers and thereby the entire weight of said superheater tubes, a rigid plate-like structure arranged transversely of said straight tube length portions at a level intermediate the height of said bank for maintaining the spacing of said tube length portions constant, said structure being predominantly monolithic and being sustained solely by tube lengths engaged thereby, said structure being disposed at a level below said gas outlet and arranged to deflect a portion of said heating gases downwardly to offset the tendency for some of said gases to bypass the lower portions of said superheater tubes in flowing toward said elevated gas outlet, and fluid heating tubes having spaced horizontally extending portions arranged adjacent the upper looped ends of said superheater tubes for limiting relative lateral movement thereof.

6. In combination with a bank of superheater tubes wherein individual tubes thereof are formed in continuous tube lengths forming groups of upwardly extending straight length portions con-

nected by loops at their upper ends and arranged for transverse flow of high temperature heating gases thereover, the straight length portions in each of said groups being arranged in rows paralleling said heating gas flow with several of said portions in each of said rows, means for supporting the weight of said tube bank entirely from below, and means for rigidly supporting said tubes laterally at a location intermediate their heights to maintain constant relative spacings between the straight length portions in a selected group, said last named means comprising a predominantly monolithic and nonmetallic plate-like member extending transversely of the tube portions of said group and being wholly supported thereby, said member engaging only the tube portions in said group and being in close fitting relation to all said tube portions in said group.

7. In a superheater having tubes arranged in bundles forming successive portions of the flow path for the fluid being heated, each bundle comprising straight length tube portions arranged upright in transverse relation to the flow of high temperature heating gases thereover in a single gas flow heating pass, said straight length portions being disposed in closely spaced rows paralleling the direction of heating gas flow with a plurality of said portions in closely spaced relation in each of said rows, means for supporting the weight of at least one of said bundles of superheater tubes entirely from one end including stationary header means to which the corresponding ends of the tubes of said bundle are connected and the tubes thereby held in fixed lateral relation only at said end of support, and means for maintaining other portions of the tubes of said end supported bundle in predetermined spaced relation in all directions laterally throughout said bundle comprising a substantially monolithic and non-metallic heat resistant plate-like member extending transversely of the straight length tube portions at a location intermediate the height of said single heating gas pass, said members embracing substantially all straight length tube portions in all of said rows in closely fitting relation to the walls thereof, said member embracing only the tubes of a single bundle and having its weight supported wholly thereby.

8. In a superheater having tubes arranged in serially connected bundles for successive flow of high temperature heating gases thereover in a single transverse pass, each bundle comprising straight length tube portions arranged upright and disposed in closely spaced relation in rows paralleling the direction of heating gas flow with a plurality of said portions in closely spaced relation in each of said rows, means for supporting the weight of said superheater tubes entirely from one end including stationary header means to which said tubes are connected and thereby held in fixed lateral relation only at said end of support, said header means including an inlet, an intermediate, and an outlet header section, said tubes being connected to said sections to provide a progressive fluid flow path from said inlet to said outlet section in a plurality of passes relative to the flow of said heating gases, one of said bundles having all of its tubes connected to said intermediate header section, a second bundle comprising a first group of tubes connected to said inlet header section and a second group of tubes connected to said outlet header section, and a heat resistant plate-like member predominantly monolithic disposed transversely of the tubes of at least said second bundle at a lo-

cation intermediate the height of said single heating gas pass for maintaining a predetermined spacing between straight length tube portions in all directions laterally throughout said bundle, said member embracing substantially all straight length tube portions in all of said rows in closely fitting relation to the tube walls, said member embracing only the tubes of a single bundle, the member for said second bundle being divided into separate relatively movable portions for said first and second groups of tubes.

9. In combination, a heat exchanger formed of tube lengths arranged upright in separate bundles and connected to provide a progressive flow path for the fluid being heated, said bundles being arranged in succession relative to the flow of high temperature heating gases thereover in a single transverse pass, said tube lengths being disposed in a plurality of closely spaced rows paralleling the direction of heating gas flow with at least several of said lengths in closely spaced relation in each of said rows, means for fixing the positions of said tube lengths at one end only of each bundle thereby leaving other portions of said tube lengths toward the opposite end of each bundle free to move in response to temperature variations, refractory plate-like members of substantially monolithic formation each arranged transversely of the tube lengths of one of said bundles and forming a separate rigid support and spacer means for the tube lengths of said bundle in all directions laterally throughout said bundle, each said member being disposed at a level intermediate the height of said tube lengths in said single heating gas pass and being sustained solely by the tube lengths engaged thereby.

10. In combination with a bundle of closely spaced superheater tube lengths arranged upright for transverse flow of heating gases thereover in a single gas flow heating pass, said tube lengths being arranged in rows paralleling said heating gas flow with several of said lengths in each of said rows, means for sustaining the weight of said bundle from one end only and for maintaining the extremities of individual tube lengths at said end in spaced relation transversely of said bundle, a slab of plastic heat resistant material hardened in place between and around said tube lengths transversely of said bundle at a location intermediate the height of said bundle, and means secured to tube lengths embraced by said slab for maintaining said slab in a predetermined position longitudinally of said bundle, said slab constituting the sole means other than said first named means for maintaining said tube lengths in predetermined spaced relation throughout their lengths.

11. In combination with a bank of inverted U-shaped superheater tubes having the major portions of their lengths straight and forming serially connected bundles of tube lengths adapted to be contacted successively by heating gases flowing transversely thereover, each bundle comprising tube lengths arranged in a plurality of rows paralleling the flow of said gases with a plurality of said tube lengths disposed in each of said rows, headers to which the lower ends of said tubes are connected including inlet and outlet headers between which steam entering said inlet header is caused to flow through said tubes to said outlet header in a plurality of passes relative to the flow of said heating gases, means for supporting said headers and thereby the entire weight of said superheater tubes, and separate plate-like means disposed transversely of the tube lengths of each

of said bundles for maintaining the spacing between said tube lengths constant without interfering with the movement of one bundle relative to another, said tube spacing means for any one of said bundles being divided into relatively movable sections at a location corresponding to the division between a plurality of said steam flow passes, each of said sections being predominantly monolithic and being supported wholly by the tube lengths with which it is associated.

12. In combination with a bundle of closely spaced superheater tube lengths arranged upright for transverse flow of heating gases thereover in a single gas flow heating pass, said tube lengths being arranged in rows paralleling said heating gas flow with several of said lengths in each of said rows, means for sustaining the weight of said bundle from one end only and for maintaining the extremities of individual tube lengths at said end in spaced relation transversely of said bundle, and a slab of plastic heat resistant material hardened in place between and around said tube lengths transversely of said bundle at a location intermediate the height of said bundle, said slab being supported solely by the tube lengths engaged thereby and constituting the sole means other than said first named means for maintaining said tube lengths in predetermined laterally spaced relation.

13. In a heat exchanger having fluid conducting tubes arranged in serially connected bundles for successive flow of high temperature heating gases thereover in a single transverse pass, each bundle comprising substantially straight tube lengths arranged upright and disposed in closely spaced relation in rows paralleling the direction of heating gas flow with a plurality of said tube lengths in closely spaced relation in each of said rows, means for supporting the weight of said tubes entirely from one end including header means having connections with said tubes arranged to provide therethrough a progressive fluid flow path divided into a plurality of fluid flow passes relative to the flow of said heating gases whereby the temperature of fluid in one pass is different from the temperature of fluid in an adjoining pass, and plate-like means disposed transversely of the tube lengths of at least one of said bundles for maintaining predetermined lateral spacing between said tube lengths, said tube spacing means for said at least one bundle being divided into relatively movable sections at a location corresponding to a division between adjoining passes of said plurality of fluid flow passes, each of said tube spacing means sections being predominantly monolithic and being supported wholly by the tube lengths with which it is associated.

JAMES D. ANDREW, Jr.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,948,939	Noack	Feb. 27, 1934
2,326,513	Bailey, et al.	Aug. 10, 1943
2,184,626	Smith, et al.	Dec. 26, 1939
1,748,113	Danks, et al.	Feb. 25, 1930
2,228,819	Emmet	Jan. 14, 1941
1,289,979	Warriner	Dec. 31, 1918
1,921,049	Tompkins	Aug. 8, 1933
1,999,984	Bailey, et al.	Apr. 30, 1935
2,158,508	Kuhner	May 16, 1939