July 3, 1962 J. N. HINDE 3,042,379

CONDENSERS

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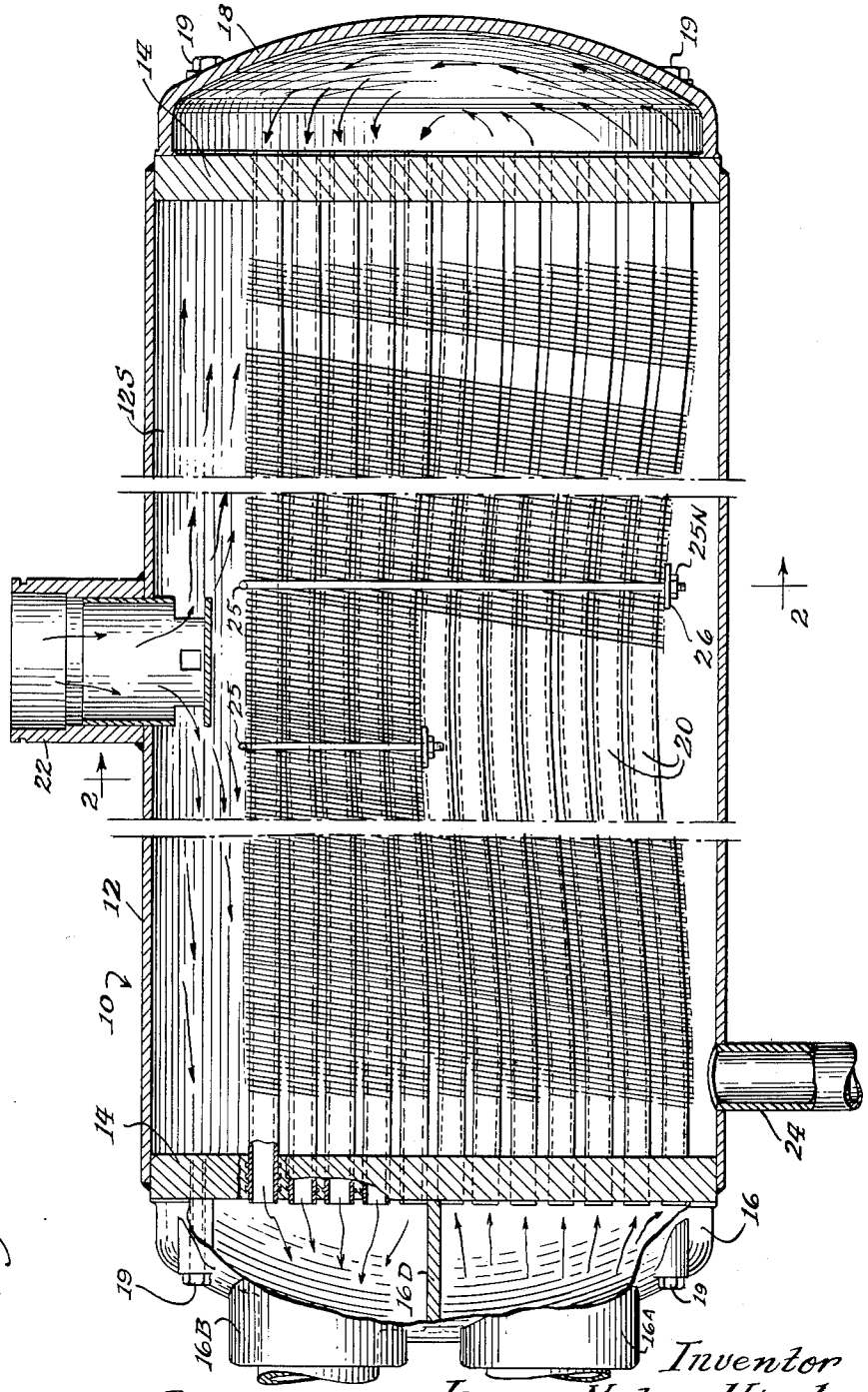


Fig. 1.

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Fig.2.

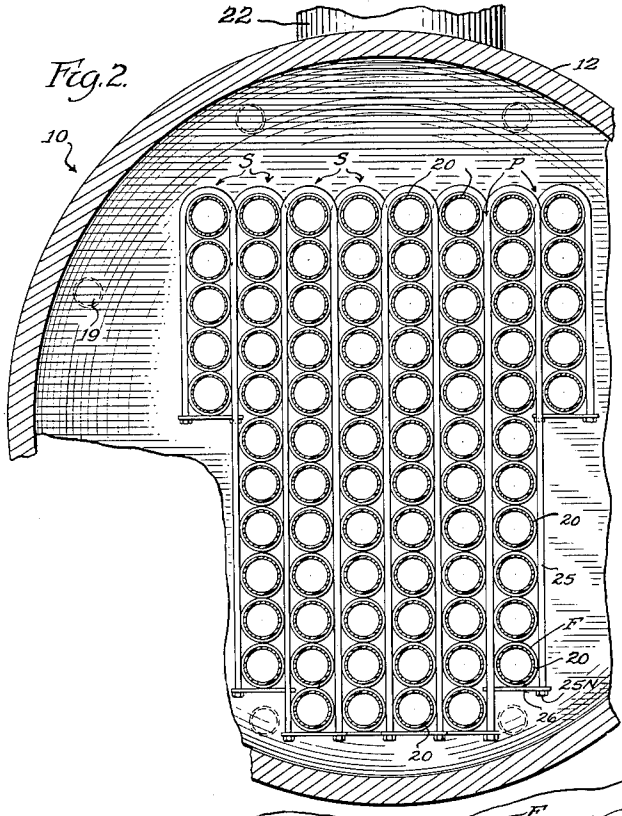
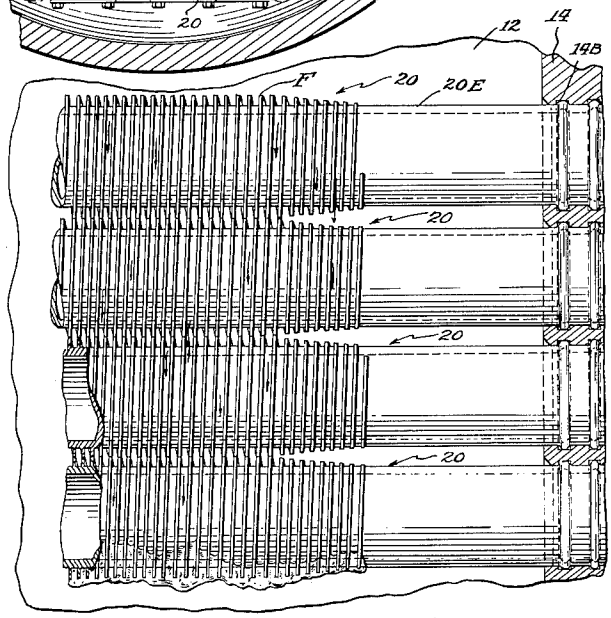


Fig.3.



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Fig. 4.

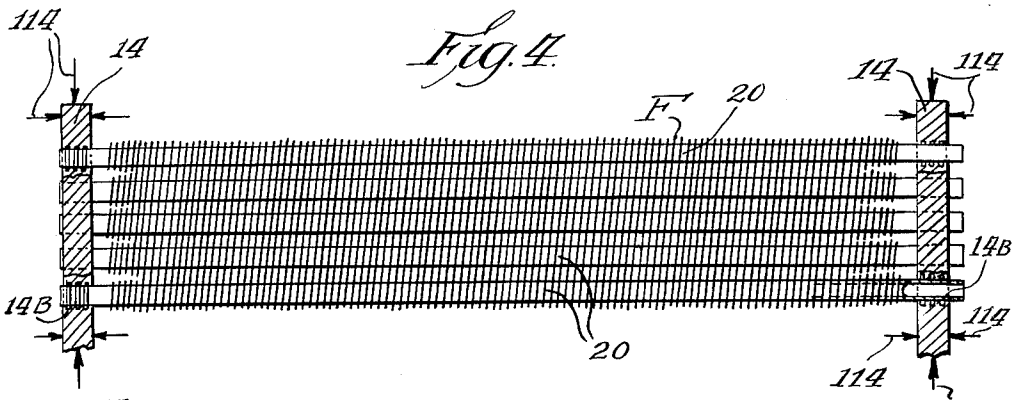


Fig. 5.

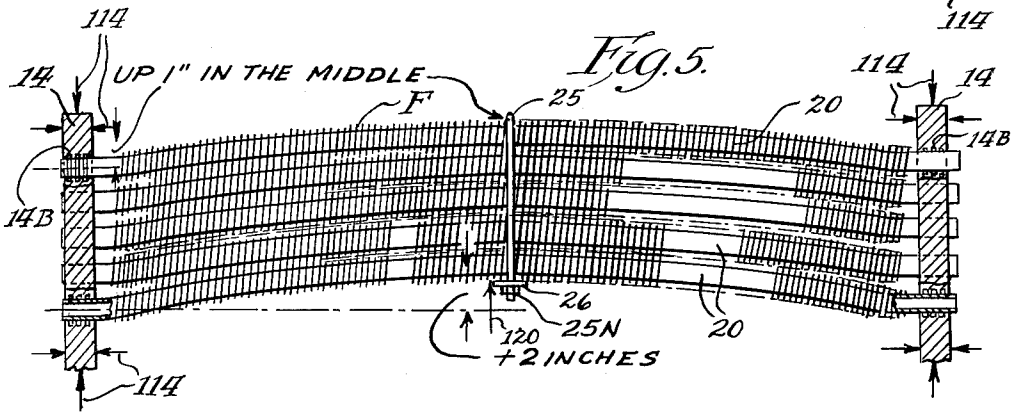
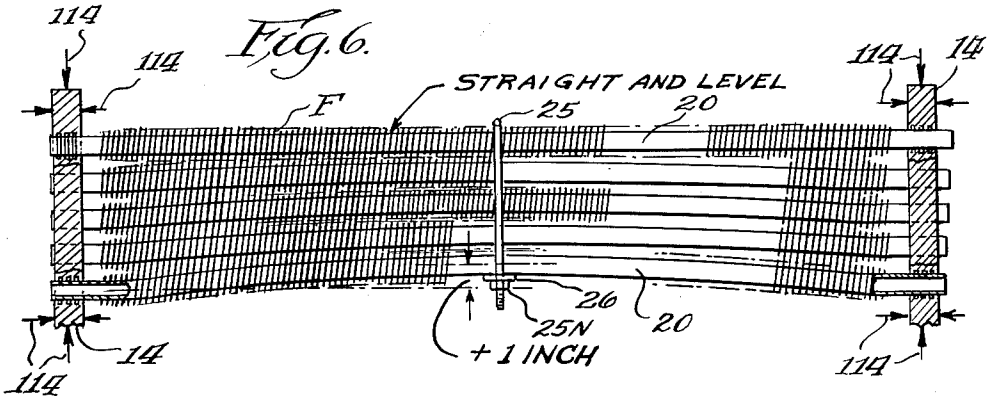


Fig. 6.



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3,042,379

CONDENSERS

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Filed June 29, 1959, Ser. No. 823,678
3 Claims. (Cl. 257—43)

This application is a continuation-in-part of my copending application Serial No. 798,616, filed March 11, 1959.

This invention relates to condensers, and particularly to shell and tube condensers that are adapted for use in refrigerating systems for the condensing of refrigerant.

Condensers of the aforesaid kind have the tubes thereof disposed horizontally within an elongated shell so that the gaseous refrigerant introduced into the upper portion of the shell may flow downwardly over the tubes so as to be condensed on the surface of the tubes which are usually of the finned type, and the condensed refrigerant is withdrawn in liquid form from the lower portion of the shell.

In my aforesaid copending application, I have disclosed and claimed a condenser of the aforesaid type wherein the finned tubes of the condenser are arranged one above the other in laterally spaced stacks so that the gaseous refrigerant may move downwardly in passages that are defined between the adjacent stacks, and in accordance with the invention disclosed and claimed in said copending application, the fins of the tubes in each stack are in substantial contact one with the other so that effectual drainage of the condensed refrigerant is attained. In the aforesaid copending application the structure also provides for holding the tubes against vibration by means of U-bolts that embrace each stack of tubes in one or more locations near the central portions of the tubes, and the U-bolts serve to assure a proper draining relation of the adjacent finned tubes in each stack.

The present invention is an improvement on the invention disclosed and claimed in my aforesaid copending application, and particularly, this invention is concerned with the arrangement and relation of the tubes of the condenser. In the use of condensers as disclosed in the aforesaid copending application, the performance has been highly satisfactory from an operational standpoint, but where condensers of this kind are mounted in outdoor locations so as to require draining of the cooling water from the condenser during the period of non-use in the winter, the usual draining operation does not in every instance drain the water from all of the tubes. As a result some damage to the tubes has been encountered due to freezing of the retained water.

In view of the foregoing it is the primary object of the present invention to provide condensers of the aforesaid character where full drainage of the tubes is assured, and a further and more specific object of the present invention is to provide a condenser embodying the advantageous characteristics of the condenser disclosed in my aforesaid copending application and having the tubes thereof so disposed that proper and adequate drainage of cooling water from the tubes will take place in the normal draining of the cooling water system.

Another and more specific object of the present invention is to provide an advantageous method of assembling condensers of the aforesaid character in such a manner that the tubes thereof will drain properly.

Other and further objects of the present invention will be apparent from the following description and claims, and are illustrated in the accompanying drawings, which, by way of illustration, show a preferred embodiment of the present invention and the principles thereof, and what is now considered to be the best mode in which to apply these principles. Other embodiments of the invention embodying the same or equivalent principles may be used and structural changes may be made as desired by those skilled in the art without departing from the invention.

In the drawings:

FIG. 1 is a vertical sectional view taken longitudinally through a liquid cooled condenser embodying the features of the invention;

FIG. 2 is a vertical cross sectional view of the condenser, the view being taken substantially along the line 2—2 of FIG. 1;

FIG. 3 is a view showing a plurality of tubes in association with each other and with a tube sheet;

FIG. 4 is a longitudinal sectional view that is somewhat schematic in character and which illustrates the first step in the assembly of the tubes on and with respect to the tube sheets;

FIG. 5 is a view similar to FIG. 4 showing the tubes after they have been assembled with the tube sheets and have been deformed so as to be bowed upwardly; and

FIG. 6 is a view similar to FIG. 5 after the upward bowing forces on the tubes have been released and the tubes have assumed their final relationship and are ready for rolling or fixing in the tube sheets.

For purposes of disclosure the invention is herein illustrated as embodied in a shell and tube type condenser **10** that comprises an elongated cylindrical shell **12** adapted to be mounted in a horizontal position and having tube sheets **14** at opposite ends thereof, end heads **16** and **18** being secured by studs **19** to the respective tube sheets **14** for directing the flow of cooling media such as water through a plurality of finned tubes **20** that extend lengthwise through the shell and are mounted at their opposite ends in tube sheets **14**. The end heads **16** and **18**, as herein shown, are so formed as to attain a two-pass operation of condenser, but this is merely illustrative. In the form shown, the head **16** has a liquid inlet **16A** and a liquid outlet **16B**, and the head **16** being divided between the inlet and outlet by a cross wall **16D**. The head **18** of course is formed without internal divisions and this arrangement thus provides for two-pass operation. The condenser **10** has a gas inlet **22** at the top of the shell **12** and a bottom outlet **24** is provided in the shell for the discharge of condensate.

The arrangement of the tubes **20** in laterally spaced stacks S so as to achieve an unusually efficient condensing operation that is described in complete detail in my aforesaid copending application, and the disclosure of such copending application, is incorporated by reference herein. It may be pointed out, however, that the ends of the tubes **20** are formed without fins as at **20E**, as shown particularly in FIG. 3 of the drawings, and these ends **20E** are extended through internally serrated openings **14B** that are formed in the tube sheets **14**. After the tubes **20** are in place, as will be described in some detail hereinafter, the tubes are internally rolled within the openings **14B** so as to interlock the tubes with the grooves of the openings **14B**.

It has been pointed out that the tubes **20** are arranged in stacks S that are spaced laterally from each other and as described in detail in my aforesaid copending application, the tubes **20** have the fins F thereof in substantial engagement with the fins F of the next adjacent tubes in the stack S.

In practice, in the initial assembly of the tubes **20** in the tube sheets **14**, the fins F of vertically adjacent tubes **20** in the stack are spaced slightly from each other, and this spacing facilitates the insertion of the ends of the tubes into the openings **14B** of the tube sheets. The spacing of the fins is obtained by arranging the openings **14B** that are to receive the tubes of a particular stack

with a vertical spacing that slightly exceeds the outer diameter of the fins F of the tubes.

As disclosed in my aforesaid copending application, the tubes **20** in each stack S are clamped together in the central portions thereof by means of one or more U-bolts **25** so that the tubes in each stack provide a relatively rigid assembly in which the individual tubes are not subject to vibration. Each U-bolt **25** extends over the tops of the stack S and downwardly beyond the lowermost tube **20** in the stack, and cross bars **26** placed on the arms of the U-bolt engage the lowermost tube and are clamped tightly by nuts **25N** that are threaded onto the lower ends of the arms of the U-bolts **25**.

The present invention is concerned with the attainment of adequate drainage of the inside of all of the tubes **20** of the condenser when the condenser is drained during the period of non-use in the winer. The arrangement is such under the present invention that such drainage is achieved by making the upper one of the tubes **20** in each stack assume either a straight horizontal form or slightly upwardly bowed form, and each of the succeeding tubes downwardly in the lowermost tube in the stack assuming a substantial upward bow, as will be evident in FIG. 1 of the drawings. Each succeeding tube above the lower tube in a stack has a somewhat smaller curve or bow therein, as shown in FIGS. 1 and 6, and the tubes of the stacks are clamped in this relation by the U-bolts **25**.

Under the present invention the above described arrangement and relative configuration of the tubes **20** of each stack S is attained in a simple manner, while at the same time retaining the fully clamped relationship of the tubes **20** of the stack, whereby the proper drainage of the condensate from the fins F is assured, proper drainage of cooling water from the inside of all of the tubes is attained, and the tubes of each stack are held as a substantially rigid assembly in which the individual tubes cannot vibrate and produce noise.

The structural assembly that has thus been described, and which is shown in FIG. 1, is produced through the series of assembly steps that are disclosed in FIGS. 4, 5 and 6. Thus, in FIG. 4 of the drawings, the tube sheets **14** are illustrated as being held in parallel and spaced relation and in the relative positions that they are to assume in the finished condenser, and these tube sheets of course have the several openings **14B** formed therein to receive the ends of the tubes **20**. This location of the tube sheets **14** may be accomplished by suitable fixtures of conventional form and design.

The tubes **20** are put in position for each of the stacks S of the tubes in succession, and FIGS. 4 to 6 illustrate the five-tube stack that is shown at the right hand side of FIG. 2 of the drawings. Each tube **20** for the stack is inserted through an opening in one of the tube sheets **14** and is then moved in the opposite direction to insert the other end of the tube into the corresponding opening of the other tube sheet, and when this is done the tube **20** is supported in the two openings **14B**, but is relatively slidable therein.

All of the tubes **20** that are to form one of the stacks S are inserted as above described so that all of the tubes **20** of the stack may be forced to a bent or upwardly bowed relationship such as that shown in FIG. 5 of the drawings, and in this operation the tubes must be free to move longitudinally in at least one of the tube sheets **14**. With this in mind, the left end of each tube is then secured in position in the left hand tube sheet **14**, as indicated in FIG. 4, while the other or right hand ends of the tubes remain in their slidable relation in the bores **14B** of the right hand tube sheet **14**. Then, while the tube sheets **14** are held in suitable fixtures as indicated by the arrows **114** in FIGS. 4, 5 and 6, the tubes **20** are bent to substantially the form shown in FIG. 5. The tubes **20** of the stack S may be laterally guided or confined by a suitable fixture engaging opposite sides of the tubes of the stack, and the upward pressure is applied, as by hydraulic means, midway between the ends of the tubes so as to force the bottom tube **20** upwardly.

The upward pressure is applied substantially at the point indicated by the arrow **120** in FIG. 5, and the several tubes **20** of the stack are bent or deformed upwardly to such an extent that the midpoint of the upper tube **20** of the stack is somewhat above the plane of the ends of the stack, a one inch over-bend being indicated as an example in FIG. 5. In other words, all of the tubes of the stack are overbent or over-stressed beyond the relationship which they are to assume in the finished condenser. As the bending takes place, of course, the free or right hand end portions of the tubes may slide, as required, within the openings **14B** of the right hand tube sheet. After the stack S of tubes have been bent upwardly to substantially the relationship shown in FIG. 5, the clamping means, which as shown constitute a single U-bolt **25**, is put in position as indicated in FIG. 5, and after putting the cross bar **26** in position, the nuts **25N** thereof are clamped so that the mid-portions of the tubes **20** have the fins F thereof in physical engagement with each other and the tubes **20** of the stack are effectually united as a substantially rigid unit, particularly at the mid-portions thereof.

After the U-bolt **25** has been tightened with the parts in the relationship shown in FIG. 5, the lifting force that has been applied at **120** as illustrated in FIG. 5, is released. When this is done, the stack of tubes **20** tends to return from the overbent or overstressed relationship shown in FIG. 5, and it may be noted that the overbending is carried to the extent required to cause the stack of tubes to return to a relationship where the uppermost tube **20** of the stack is substantially straight or is bowed slightly in an upward direction. During the foregoing operation, the tube sheets **14** are maintained in their fixed original relationship, and as the stack of tubes **20** returns from its overbent relation, the free or right hand end portion of the tubes may move as required in an endwise relationship in the opening **14B** of the tube sheets.

The tubes **20** are then ready for anchoring of the other or right hand ends in the tube sheets, and this is accomplished in the usual manner as by internal rolling of the end portions of the tubes **20** within the openings **14B**, thus to provide external annular beads that engage with the internal serrations of the openings **14B**. The projecting ends of the tubes may then be trimmed.

The assembly of the other stacks of tubes **20** is then carried out in succesison in a imilar manner until all of the tubes **20** have been put into position between the tube sheets **14**. The assembly then constitutes a rigid assembly wherein the tube sheets **14** are rigidly interconnected by the several stacks of tubes **20**, and the asesmbly is thus in condition for application of the shell **12** and the related parts to produce the complete condenser.

It may be noted that while both ends of the tubes **20** might be left free for endwise movement in the tube sheets during the bending and clamping operations, the procedure is simplified by first securing one end of each tube in position as above described. Thus by this procedure, the originally ecured ends of the tubes do not require trimming; overpulling of the tubes in one of the tube sheets is avoided, and the tubes are held against twisting or turning during the application and release of the bending forces.

From the foregoing it will be apparent that the present invention provides an improved water cooled condenser wherein the finned tubes are so arranged that there is not only a great increase in the efficiency of the condensing action, but also the tubes are clamped together in such a way that the tubes cannot vibrate and cooling water will be drained properly from the tubes during the periods of non-use in the winter.

It will also be apparent that the present invention provides the new and highly advantageous method of assem-

bly of condensers whereby the tubes may be arranged and clamped in such a way as to assure proper drainage of the tube.

Thus while I have illustrated a preferred embodiment of the invention, it is to be understood that changes and variations may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

I claim:

1. In a shell and tube condenser, a casing including a shell and tube sheets with housings associated with the tube sheets to provide coolant inlet and outlet passages and said shell having a top inlet for gas and a lower outlet for condensate, a plurality of finned tubes connecting said tube sheets within such shell, said tubes being arranged in laterally spaced vertical stacks with the fins of vertically adjacent tubes in said stacks being in substantial engagement one with the other, and means clamping the tubes of each stack together adjacent to midpoints of the stacks with the upper tube of each stack substantially straight and with the successive tubes downwardly of said upper tube being curved into an upwardly bowed arrangement so that the lower tube has the greatest upward bow and all of the tubes of each stack are maintained in a substantially rigid relationship to each other.

2. In a shell and tube condenser, a shell and tube sheets with housings associated with the tube sheets to provide coolant inlet and outlet passages, said shell having a gas inlet and a condensate outlet, a plurality of finned tubes within such shell extending between and through said tube sheets, said tubes being ararnged in laterally spaced vertical stacks with the fins of vertically adjacent tubes in said stacks being in substantial engagement one with the other, and U-bolts embracing the respective stacks and clamping the tubes of each stack together adjacent to midpoints of the stacks with the upper tube of each stack substantially straight and with the tubes downwardly of said upper tube being curved into an upwardly bowed arrangement.

3. In a shell and tube condenser, a casing including a shell and tube sheets with housings associated with the tube sheets to provide coolant inlet and outlet passages, said shell having a top inlet for gas and a lower outlet for condensate, a plurality of finned tubes extended between and through said tube sheets, said tubes being arranged in laterally spaced vertical stacks with the fins of vertically adjacent tubes in said stacks being in substantial engagement one with the other, and means embracing the tubes of each stack as a group and clamping such tubes together, in the central portions of the stacks all of the tubes below the upper tube of the stack being curved into an upwardly bowed arrangement and with the upper tube substantially straight.

References Cited in the file of this patent

UNITED STATES PATENTS

1,363,208	Serck	Dec. 21, 1920
1,550,368	Kirgan	Aug. 18, 1925
1,641,975	Jones	Sept. 13, 1927
1,741,121	Winslow	Dec. 24, 1929
1,780,781	Ehrhart	Nov. 4, 1930
1,788,386	Ehrhart	Jan. 13, 1931
2,176,873	Hughes	Oct. 24, 1939
2,720,383	Huet	Oct. 11, 1955
2,830,797	Garland	Apr. 15, 1958

FOREIGN PATENTS

310,327	Great Britain	July 16, 1930