March 3, 1970 W. P. GORZEGNO ET AL 3,498,270

ALL-WELDED FURNACE CONSTRUCTION

Filed May 1, 1968 2 Sheets-Sheet 1

FIG. 1

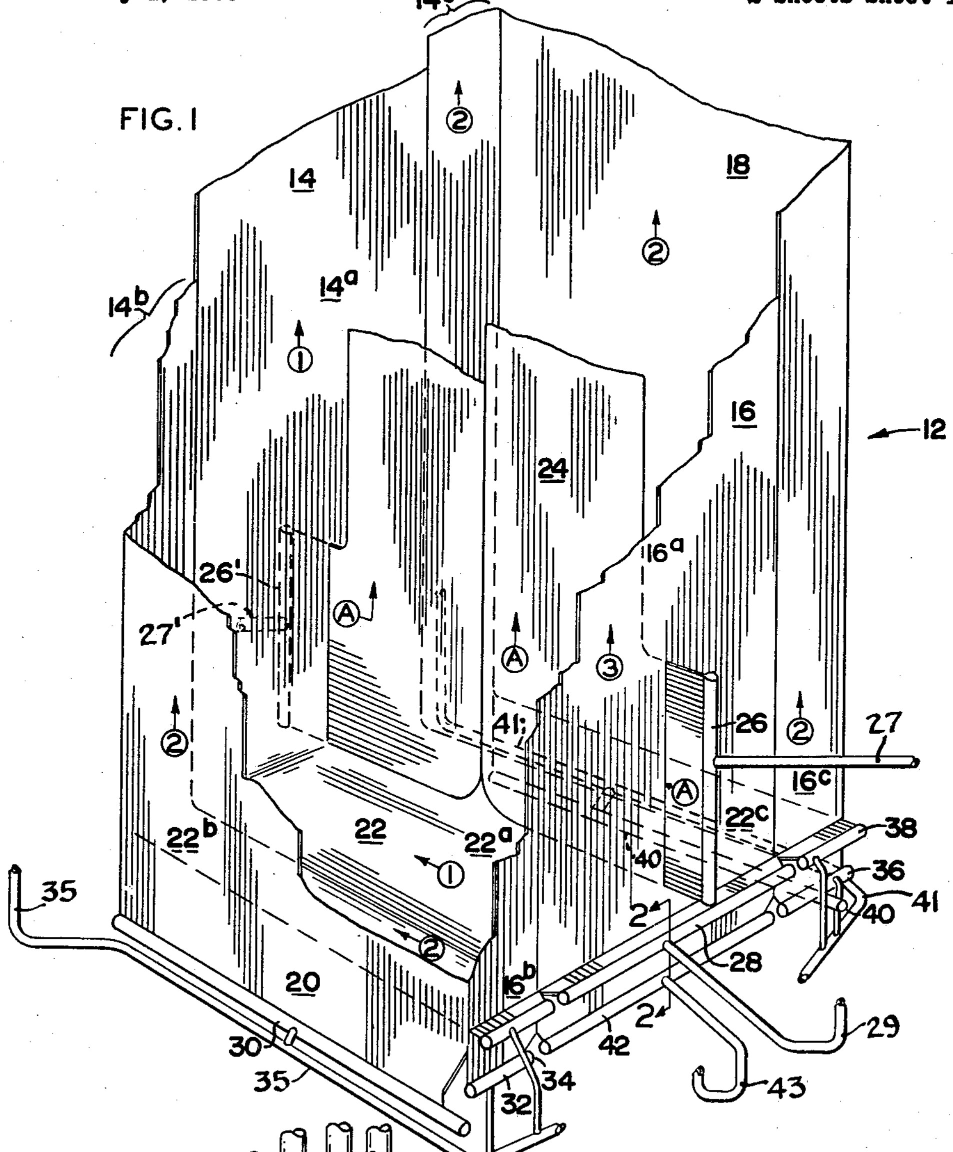
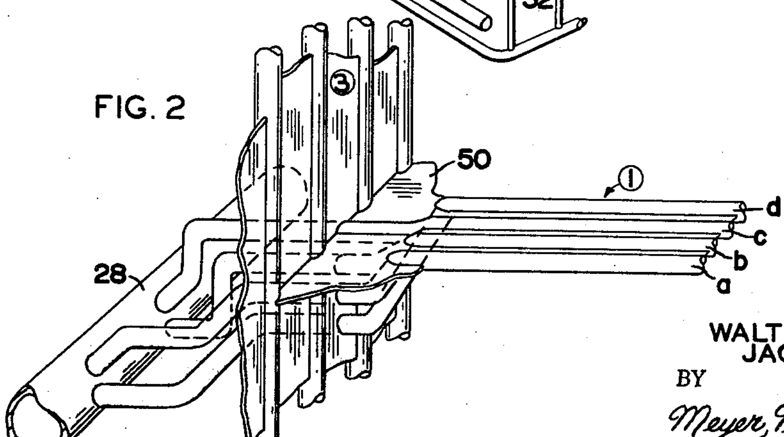


FIG. 2



INVENTORS
WALTER P. GORZEGNO
JACOB COOPER

BY

Meyer, Tilberry & Body

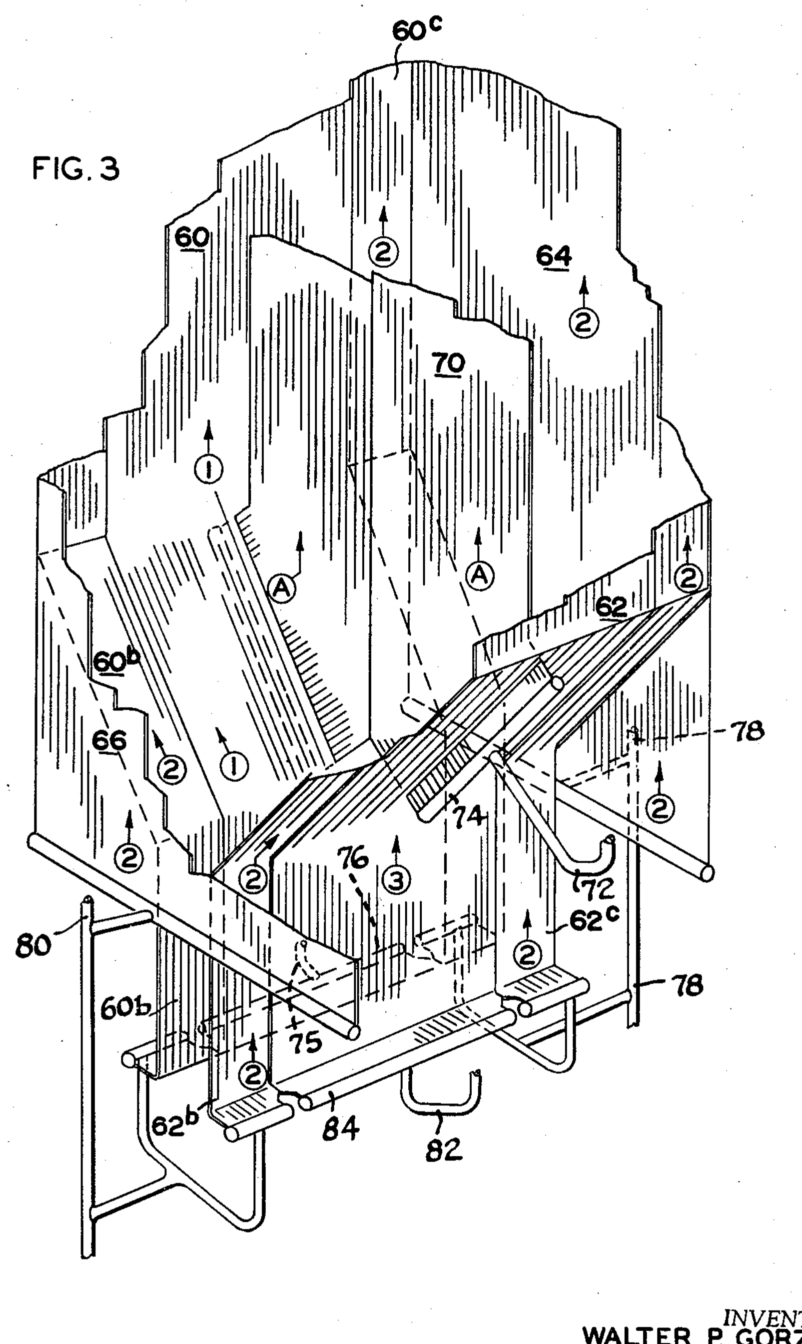
ATTORNEYS.

March 3, 1970 W. P. GORZEGNO ET AL 3,498,270

ALL-WELDED FURNACE CONSTRUCTION

Filed May 1, 1967 2 Sheets-Sheet 2

FIG. 3



INVENTORS
WALTER P. GORZEGNO
JACOB COOPER
BY
Meyer, Tilberry & Body
ATTORNEYS.

United States Patent Office
3,498,270
Patented Mar. 3, 1970

1

3,498,270

ALL-WELDED FURNACE CONSTRUCTION

Walter P. Gorzegno, Florham Park, N.J., and Jacob Cooper, Los Angeles, Calif., assignors to Foster Wheeler Corporation, Livingston, N.J., a corporation of New York

Filed May 1, 1968, Ser. No. 725,764
Int. Cl. F22d *1/10;* F28d *7/00;* F28f *1/22*
U.S. Cl. 122—406 8 Claims

ABSTRACT OF THE DISCLOSURE

An all-welded furnace construction wherein the walls of the furnace are formed of a plurality of passes in series, each pass occupying a portion of the furnace periphery. The design of the furnace is such that it permits the all-welded type construction to be used even in the bottom or lower portion of the furnace. In particular, the corners of the furnace are comprised of tubes of the same pass to permit the lower or bottom corners to be welded together, and the layout of the passes is such that one pass will be adjacent in its longitudinal dimension to a pass which either immediately precedes or immediately follows it in the flow circuitry. The invention is applicable to both a flat bottom type of furnace and a hopper bottom type of furnace.

The present invention relates to an all-welded furnace construction for vapor generators of the once-through type, and in particular to a novel all-welded construction for the furnace bottom.

The all-welded construction or design is that construction or design wherein the tubes or the fins of parallel finned tubes are welded together, for instance along their lengths, so that a surface comprised of the tubes is gas tight without the need for seal plates and/or refractory.

A once-through vapor generator is defined as a generator wherein the flow is forced through the tubes of the generator without recirculation. In the smaller generators of past years, the flow was usually transmitted in a single tube pass defining the generator furnace walls, and then was transmitted through super-heating passes in a convection area of the furnace to a point of use. As the generators have become larger in dimension, present generators having a furnace section in the order of eighty by forty feet in width and depth, with large numbers of burners disposed on opposite front and rear walls of the furnace, it has become apparent that special precautions are necessary to assure an equal flow distribution in the tubes of the furnace walls. For instance, tubes in the center of a wall may have a greater heat absorption than tubes in a corner of the furnace, resulting in unequal or unbalanced fluid and metal temperatures, and flow upsets.

In prior Patent No. 3,324,837, issued June 13, 1967 assigned to assignee of the present application, there was described a furnace pass arrangement in which the furnace walls were divided into a plurality of upwardly extending parallel passes, the passes being connected together by suitable downcomers for series flow through the passes. This unique arrangement had the outstanding advantage of minimizing the furnace periphery cooled by any one pass, and according, minimizing the danger of a flow upset between areas of a given pass. In addition, the passes were arranged in the furnace so that a given

2

tube in a wall was always adjacent to a tube at the same metal and fluid temperature, or at a temperature sufficiently close so that differential thermal expansion resulting thermal stress between adjacent tubes was kept within safe limits.

A problem has always existed with respect to the construction and design of the lower portion of the furnace or the furnace bottom, particularly for a furnace which is maintained at above atmospheric pressure. Because the burners are disposed near the bottom of the furnace, the bottom is subjected to extreme heat effects, and in addition is subjected to the severe chemical effects of combustion, particularly if a pulverized solid fuel is used where the imcombustible elements of the fuel arrive at the bottom in a molten state. Efforts have been made to seal the bottom using plates or refractory or both, but such efforts have not always been entirely satisfactory. Although the possibility of slag break-through or leakage has been considerably reduced, the action of slag on refractory has required considerable maintenance when refractory is used. The use of seal plates requires considerable exact fitting and welding which is expensive in the field, and accompanied with the danger of accidental burning or cutting of tubular pressure parts. The design and construction of the furnace bottom, which has always been a complicated and expensive part of the construction of a vapor generator, is further complicated when the furnace is constructed of a plurality of passes in series by the differential thermal expansion stresses which result.

It is an object of the invention to provide an all-welded multi-pass furnace construction wherein the all-welded feature is continued into the bottom or lower portion of the furnace.

A further object of the invention is to minimize fit-up and field welding costs and to simply the furnace bottom construction.

The invention is applicable to two types of furnaces, a hopper bottom type furnace, or a flat bottom type of furnace which is coal, oil or gas fired. In the case of coal firing, the furnace would be of the slag-tap type.

In accordance with the invention there is provided a rectangular upright furnace enclosure including first and second oppositely facing walls and side walls therebetween or intermediate the first and second walls. A plurality of parallel upright finned tubes welded together define each of the walls and said furnace enclosure. A plurality of headers are connected to predetermined groups of tubes to divide the furnace enclosure walls into a plurality of flow passes, there also being provided a plurality of downcomers connecting the passes so that the passes are in series. The walls are divided preferably into at least three flow passes, with the oppositely facing first and second walls being predominantly comprised of tubes of the first and third passes, the intermediate side walls constituting tubes of the second pass. The headers, and connections between the headers and tubes, are arranged so that the intermediate second pass extends around the corners of the furnace enclosure to occupy portions of the ends of the first and second walls adjacent the intermediate walls, the upright corners thereby being comprised of tubes of the same pass. By the above arrangement, the tubes of any one pass will always be adjacent to tubes of the same pass or of either a preceding or following pass, along the lengths thereof.

In a preferred embodiment, in connection with a flat bottom type generator utilizing a flat floor, the sides of the floor adjacent the furnace side walls are comprised of tubes of the second pass, so as to avoid stress between the floor and side walls, and in the three dimensional corners consisting of the opposite first and second walls, the side walls and the floor, the tubes defining each corner are all at the same temperature. Preferably the remainder center portion of the floor is comprised of tubes of the first pass which then extend on upwardly in said first upright wall of the furnace enclosure.

The above arrangement permits welding the walls and floor together using the fin-tube all-welded construction in the lower portion or bottom of the furnace and eliminates or minimizes the use of seal plates and refractory and the accompanying disadvantages of both.

The invention and advantages thereof will become apparent upon further consideration of the following specifications, with reference to the accompanying drawings, in which:

FIGURE 1 is a perspective partially broken-away view illustrating the invention in connection with a gas-fired flat bottom once through vapor generator or a slag-tap type of coal fired generator;

FIGURE 2 is a section view taken through line **2—2** of FIGURE 1; and,

FIGURE 3 is a perspective partially broken-away view of a dry ash hopper bottom type generator in accordance with the invention.

Referring to the drawings, and in particularly, FIGURES 1 and 2, there is illustrated a furnace enclosure **12** consisting of first and second (hereafter called front and rear walls) walls **14** and **16**, and side walls **18** and **20** between or intermediate the front and rear walls. Along the floor is a flat bottom wall **22**, and extending upwardly along the middle of the furnace enclosure is an upwardly extending division wall **24**. The generator can be fired by coal, gas, or oil by burners which are not shown and for coal firing the flat bottom arrangement of FIGURE 1 would be provided with a suitable slag tap, also not shown. The division wall is not required, but is utilized with the larger furnaces of today for the purpose of introducing further heat absorption surface into the furnace enclosure.

Each of the side and front and rear walls is made up of a plurality of upwardly extending parallel flow tubes while the floor is made up of a plurality of parallel horizontally extending tubes, which extend parallel to the side walls between the front and rear walls, and the division wall is made up of a plurality of tubes which enter the furnace enclosure in a horizontal direction and are disposed in a vertical plane and which are then bent to extend upwardly in the middle of the furnace enclosure in a vertical plane parallel to the sidewalls **18** and **20**.

As shown in FIGURE 1, all of the walls, including the floor and division walls are divided into passes by being connected at their lower ends to a plurality of inlet headers. In the arrangement illustrated, the division wall makes up a first pass "A," receiving a fluid flow from the economizer (not shown) of the generator, and from the division wall the flow is transmitted to a first furnace enclosure pass "1" made up of tubes of the bottom wall **22** of the furnace and also tubes of the front wall **14**. From the outlet header of the front wall, the flow is transmitted to a second pass "2" consisting primarily of tubes of the sidewalls **18** and **20** of the furnace enclosure. Finally, the flow is transmitted through a third pass "3" of the furnace enclosure defining primarily the rear wall **16** of the enclosure.

The arrangement can be easily visualized by referring specifically to the inlet headers for the various passes. For the division wall tube pass "A" there is provided a first pair of headers comprising opposite vertically extending headers **26** and **26′** outside of the upright rear and front walls **16** and **14**. The flow from the economizer section of the generator is distributed equally to these two headers by conduits **27** and **27′** for uniform distribution of flow in the division wall. From the division wall, the flow is through a suitable downcomer **29** to a single header **28** for the first enclosure pass "1." The header **28** is parallel to and outside of the rear wall **16** in a horizontal plane approximately coplanar with the floor or bottom wall **22** and is connected to a center section **22*a*** of tubes of the flat bottom wall **22**, making up most of the bottom wall or floor. These tubes are simply bent upwardly when reaching the front wall **14** so that this pass of tubes also makes up predominently the front wall of the furnace enclosure portion **14*a***. From the outlet of the first pass, the flow is transmitted uniformly to a plurality of inlet headers **30**, **32**, and **34** through downcomer **35**, and to inlet headers **36**, **38** and **40** through downcomer **41**, these inlet headers being connected to tubes which make up pass "2," comprising the entire sidewalls **18** and **20** of the furnace enclosure (headers **30** and **40**), the side portions **16*b*** and ***c*** of the rear wall **16** (headers **32** and **36**) and also side portions **22*b*** and ***c*** of the bottom wall or floor **22** (headers **34** and **38**). These latter portions extend on upwardly along sides of the pass "1" tubes **14*a*** of the front wall **14** as panels **14*b*** and ***c***. Finally the flow is returned to header **42**, through downcomer **43**, for the rear wall **16** for pass "3," this pass being defined by tubes **16*a*** constituting most of the rear wall of the enclosure.

FIGURE 2 illustrates the construction of the furnace where the pass "1" floor tubes intersect the pass "3" wall tubes. The tubes of pass "3" are all fin-welded together, and the pass "I" tubes which intersect the pass "3" wall are seal welded to the latter. The pass "3" tubes are all aligned in a vertical plane, and the pass "1" tubes are for the most part in a horizontal plane within the furnace enclosure, except in the area adjacent to the pass "3" wall. In this area the tubes are grouped into groups of four and the *a*, *b* and *d* tubes are bent downwardly and towards the *c* tube to pass through the pass "3" wall in the same vertical plane as the pass *c* tube, aligned vertically with the latter. Outside of the rear wall, the tubes are connected to header **28** in groups of two, as shown. The principle advantage of this arrangement is that it reduces the number of penetrations required in the rear wall. A long scalloped seal plate **50** the opposite edges of which are cut away so that the bar can be seal welded to the tubes of passes "3" and "1" is horizontally welded into the corner between the rear and bottom walls sealing the corner. The result is that the differential lateral expansion between passes "1" and "3" is absorbed by the plate **50** rather than in weld joints between the tubes of passes "1" and "3."

In the front and rear walls **14** and **16**, the pass "2" tubes occupy sufficient areas of these walls, perhaps a dozen tubes or a foot or more in from either side wall, so that the differences in expansion experienced between passes "2" and "3" and passes "2" and "1" are distributed over a number of tubes before the corners are reached.

Along the bottom corners of the furnace, stresses are also minimized. Between the bottom wall **22** or floor, and the side walls **18** and **20**, the tubes are at the same temperature. Between the bottom wall or floor **22** and the front wall **14**, there is no stress pattern, since the bottom wall tubes are simply bent upwardly to make up the front wall. In the rear wall **16**, the tubes of the bottom wall or floor are grouped together in groups of four to pass in a vertical plane through the vertical wall and a fairly long plate member **50** sealing the bottom and rear wall corner takes up the stresses caused by any temperature differences between the tubes of these walls. In the very critical three dimensional corners the tubes are all at the same temperature.

Referring back to FIGURE 1, it is evident that the invention minimizes stresses at the bottom of the furnace enclosure, permits welding most of the furnace enclosure walls including the floor together to produce a tighter enclosure and reduces the use of seal plates and fit-up and welding which accompanies such use.

A further advantage of the invention should also be evident, namely that the passes are arranged so that for the most part the end-most tubes of any one pass will be adjacent to tubes of either a succeeding pass or a following pass. In other words, the pass "1" tubes will not be adjacent to the pass "3" tubes along a longitudinal seam. Referring to the side walls, there is obviously no problem. In the front wall **14**, and along the bottom wall **22**, the end-most tubes of pass "1" are adjacent to pass "2" tubes. In the rear wall **16**, the end-most tubes of pass "3" are adjacent to pass "2" tubes.

FIGURE 3 illustrates the invention with a hopper bottom type furnace. In this type of furnace, coal is usually burned, although the furnace may also be oil fired. The hopper is usually provided with a water seal, and the dry ash discharges through the hopper into a suitable container at the bottom of the hopper.

In this embodiment, the tubes of pass "1" make up a predominant portion of the front wall **60** of the furnace, the rear wall **62** being predominantly pass "3" tubes. Pass "1" is connected in series with pass "2" the tubes of which make up the side walls **64** and **66** of the furnace and narrow end portions **60***b* and *c* and **62***b* and *c* of the front and rear walls **60** and **62**. It is apparent that the upwardly extending four corners of the furnace including the area of the hopper throat will be composed of pass "2" tubes at the same temperature eliminating stresses at these corners. Again pass "2" has enough tubes or occupies a sufficient part of the front and rear walls so that the stresses existing in these walls will be distributed over a fairly long distance before reaching the corners.

If desired, a division wall **70** can be utilized in this type of furnace to make up a pass "A" passing upwardly in the middle of the furnace. These tubes of the division wall pass through the sloping hopper portions of the front and rear walls and then are bent to extend upwardly in a plane parallel to and intermediate the two side walls.

Pass A is furnished water from the economizer by downcomers **72** and headers **74**. Only one downcomer **72** and one header **74** are shown but it will be understood that another of each of these elements is provided on the obscured side of the furnace. From the top of division wall **70**, fluid is carried by downcomer **75** to the header **76** which feeds the pass "1" tubes. From the top of pass "1," the fluid is carried down downcomers **78** and **80** to headers at the bottoms of the pass "2" tubes, that is the tubes which make up the side wall **64** and **66**, the end portions **60***b* and **60***c* of the front wall **60** and the end portions **62***b* and **62***c* of the rear wall **62**. From the top of the pass "2" tubes, the fluid is fed down downcomer **82** to header **84** which distributes fluid to the pass "3" tubes in the rear wall **62**.

Although the invention has been described with reference to specific embodiments, variations within the scope of the following claims will be apparent to those skilled in the art.

What is claimed is:

1. An all-welded furnace construction comprising
- a rectangular furnace enclosure including first and second oppositely facing walls and side walls therebetween;
- a plurality of substantially parallel upright finned tubes welded together to define each of said walls and said furnace enclosure;
- a plurality of headers connected to said tubes, each header being connected to preselected groups of tubes so that said enclosure is divided into a plurality of flow passes;
- means connecting the headers so that the flow passes are in series;
- the headers and tube connections being arranged so that the tubes adjacent to and on opposite sides of the enclosure corners defining each corner will be of the same flow pass.

2. A furnace construction according to claim **1** wherein said furnace enclosure comprises at least three flow passes in series, the first wall comprising predominantly tubes of the first pass and the second wall comprising predominantly tubes of the third pass, said side walls and areas of said first and second walls adjacent the side walls comprising tubes of the second pass.

3. A furnace construction according to claim **2** wherein said furnace enclosure further includes a floor, the floor comprising predominantly tubes of the first flow pass which are bent to extend upwardly in said first wall, the areas of said floor adjacent the side walls comprising tubes of the second pass which are also bent upwardly in the first wall coplanar with the first pass tubes to define said areas of the first wall adjacent the side walls.

4. A furnace construction according to claim **3** wherein the floor and first wall areas occupied by said second pass tubes are substantially of the same width.

5. A furnace construction according to claim **4** wherein the areas of said second wall occupied by the second pass tubes are substantially equal in width to the areas occupied by the second pass tubes in the floor and first wall.

6. A furnace enclosure according to claim **1** wherein said furnace is of the hopper bottom type.

7. An all-welded furnace construction comprising
- a rectangular furnace enclosure including first and second oppositely facing walls and third and fourth walls therebetween;
- a plurality of parallel upright finned tubes welded together to define each of the walls and said furnace enclosure;
- a plurality of horizontal parallel floor tubes extending between the first and second walls to define the furnace enclosure floor;
- means connecting the floor tubes to the first and second wall tubes to present a gas-tight construction;
- means seal welding the floor tubes to the third and fourth walls;
- a plurality of header means connected to the furnace enclosure tubes including the floor tubes so that the enclosure including the floor is divided into a plurality of flow passes;
- means connecting the passes in series so that tubes of the flow passes are at different temperatures;
- the header means for the third and fourth walls also supplying a cooling fluid to a limited number of the floor tubes and a limited number of first and second wall tubes adjacent the third and fourth walls whereby the three-dimensional corners defined by the floor and four walls are comprised of tubes at the same temperature.

8. An all-welded furnace construction comprising
- a rectangular furnace enclosure including first and second oppositely facing walls and third and fourth walls therebetween;
- a plurality of parallel upright finned tubes welded together to define each of the walls and said furnace enclosure;
- said first and second walls being sloped to converge inwardly near the bottom of the furnace enclosure to define a furnace hopper bottom;
- means seal welding the sloping hopper portions of the first and second walls to the third and fourth walls therebetween;
- a plurality of header means connected to the furnace enclosure tubes so that the enclosure is divided into a plurality of flow passes;

means connecting the passes in series so that tubes of the flow passes are at different temperatures;

the header means for the third and fourth walls also supplying a cooling fluid to a limited number of tubes of the sloping hopper bottom of the first and second walls adjacent the third and fourth walls whereby the corners of the hopper are comprised of tubes at the same temperature.

References Cited

UNITED STATES PATENTS

3,237,612	3/1966	Koch et al.	122—406
3,324,837	6/1967	Gorzegno et al.	122—406
3,344,777	10/1967	Gorzegno	122—406

KENNETH W. SPRAGUE, Primary Examiner