United States Patent [19]

Kennedy

[11] **3,807,382**

[45] **Apr. 30, 1974**

[54] **HEAT EXCHANGE SHELL HAVING AN OFFSET SEAM**

[75] Inventor: **Waldron Nathaniel Kennedy,** Cedar Rapids, Iowa

[73] Assignee: **Lear Siegler, Inc.,** Santa Monica, Calif.

[22] Filed: **Mar. 10, 1972**

[21] Appl. No.: **233,614**

[52] **U.S. Cl.** ..... **126/116 R**

[51] **Int. Cl.** **F24h 3/00**

[58] **Field of Search** ..... 126/116 R, 110 R

[56] **References Cited**

UNITED STATES PATENTS

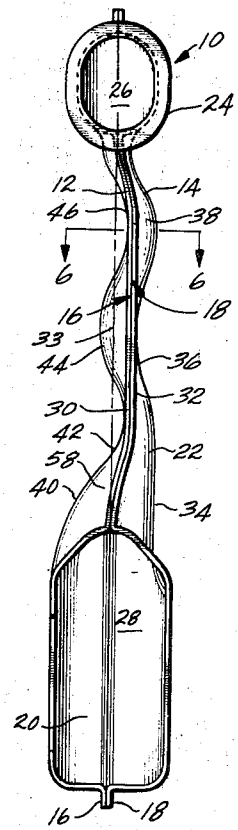
3,294,082	12/1966	Norris	126/110 R
3,638,636	2/1972	Marshall et al.	126/116 R
1,927,174	9/1933	Jones	126/116 R

Primary Examiner—Charles J. Myhre
Assistant Examiner—Sheldon J. Richter
Attorney, Agent, or Firm—Christie, Parker & Hale

[57] **ABSTRACT**

A heat exchange shell of the type used in home furnaces has a convoluted heat exchange section bounded on its bottom and top, respectively, by a combustion chamber and a flue gas collector. Two half shells are welded together along seams which circumscribe the shell generally in a plane which bisects both the flue gas collector and the combustion chamber. The seam in the intermediate heat exchange section, however, is offset slightly from this plane such that the convoluted wall of each half of the shell is always on only one side of the middle of the seam.

15 Claims, 6 Drawing Figures



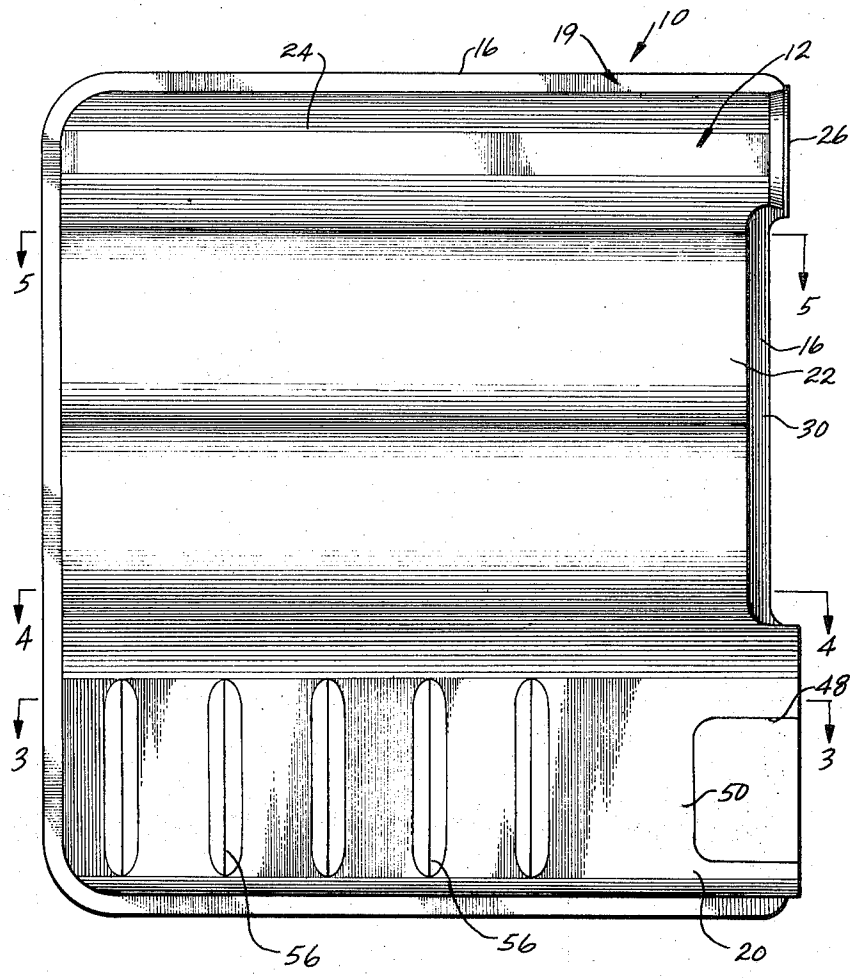

24
16
19
10
12
26
5
5
16
22
30
4
4
48
3
3
50
56
56
20

FIG. 1

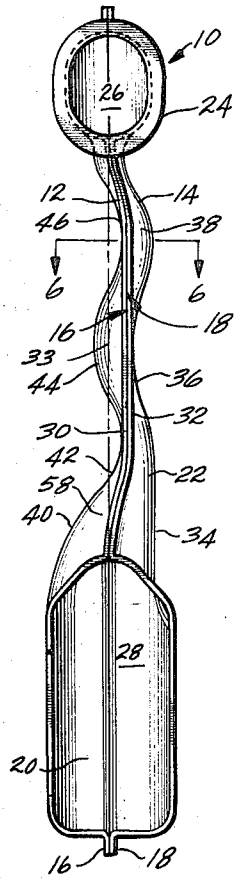

10
26
24
12
14
46
38
6
6
16
18
33
44
36
30
32
42
22
58
40
34
28
20
16
18

FIG. 2

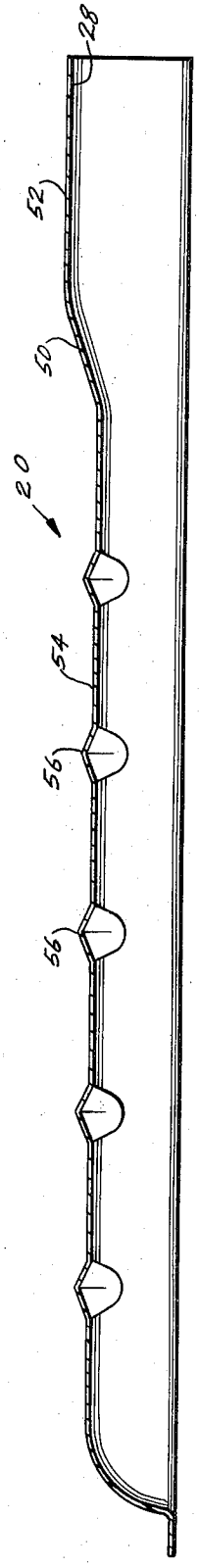


FIG. 3

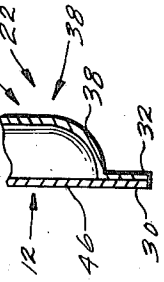


FIG. 6

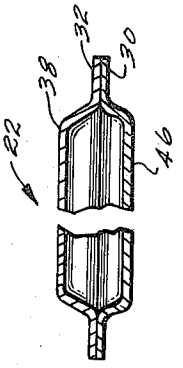


FIG. 5

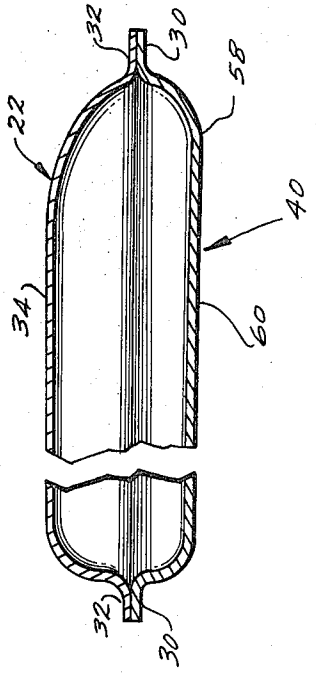


FIG. 4

HEAT EXCHANGE SHELL HAVING AN OFFSET SEAM

BACKGROUND OF THE INVENTION

The present invention relates to heat exchange shells of the type used in home furnaces and, more in particular, to an improved heat exchange shell of the convoluted heat exchange section type which has a joining seam between shell halves in the heat exchange section which is offset from a vertical plane passing through the shell's flue gas collector and combustion chamber.

Heat exchange shells of the type pertinent here are tall and deep, while relatively thin.

A heat exchange shell is used in forced air furnaces to provide a place for combustion, a heat exchange section to transfer heat from products of combustion to air passing along the outside of the shell, and a flue gas collector for receiving the products of combustion and exhausting them to a flue. Typically, a plurality of two or more heat exchange shells are mounted side by side within a furnace, and air to be heated is blown past them by a blower. There is a burner in each combustion chamber.

Obviously, domestic home furnaces should be as compact as possible, consonant with reasonable furnace cost and heating efficiency. The overall size of a heat exchange shell can be made relatively small by efficient design of the shell's heat exchange surfaces, that is, by providing heat exchange surfaces which optimize heat transfer from the outside surface of the shell to passing air and from products of combustion to the walls of the shell. One way of doing this is to have the heat exchange section convoluted in order to promote scrubbing by combustion gases of the interior heat exchange surfaces of the shell and by air passing along the exterior heat exchange surfaces of the shell.

Typically, heat exchange shell halves are drawn with a punch and a die.

One form of prior art heat exchange shell having a convoluted wall heat exchange section has been constructed by welding together a pair of complementary half shells around planar welding flanges to form a seam. Each of the shell halves was formed of a metal drawing. In an assembled heat exchange shell, the planar, joining seam bisected the flue gas collector and the combustion chamber. The convolutions of one or the other or both of the walls of the heat exchange section often passed through the plane of the joining seam. Another prior art construction has a seam line which follows the convolutions in the intermediate, heat exchange section. The seam line which followed the convolutions passed from one side to the other of the medial plane bisecting the flue gas collector and the combustion chamber.

Heat exchange shell design requires that the shell be economically produced, reliable in service, and have effective and efficient heat transfer characteristics. Reliability in service is made difficult because service conditions find the shell undergoing cyclic heating and cooling with the result that the metal of the shell is constantly undergoing expansion and contraction. The resulting thermally induced stresses can cause fatigue failure, which of course is unacceptable. The possibility of fatigue failure can increase from strain in the shell from the drawing process. The possibility of unduly stressed walls increases with the amount of metal which

is moved, and with the number and frequency of different types of stresses imposed on the metal, stress types being, for example, tension, compression, bending and twisting. Obviously, as well, production costs must be maintained as low as possible for a competitive shell. This means that tooling costs should be reasonable and that the design be such that tooling wear will be minimized.

SUMMARY OF THE INVENTION

The present invention provides an improved heat exchange shell which is characterized in having the joining marginal edges, preferably welding flanges welded into a seam, between shell halves offset from the plane which bisects the flue gas collector and combustion chamber of the shell such that the convoluted wall of each half of the shell is on only one side of the middle of the seam. The middle of the seam may be viewed as an imaginary surface between the welding flanges. Stated alternatively, at least one of the convoluted walls of the intermediate heat exchange section of the shell passes through a medial plane bisecting the flue gas collector and the combustion chamber. The weld seam line is offset enough from the medial plane so that no wall of the heat exchange section passes through an imaginary surface which follows the middle of the weld seam.

With the construction of the present invention the drawing dies and punches used to fabricate the shell halves are simple and reliable. In addition, the shell halves themselves are not worked to such an extent as to cause possible failure problems in the drawing process or residual stress which could cause failure in service. In addition, the offset seam is largely straight and as a consequence it is much easier to weld shell halves together along the flanges constituting the seam than is the case with welding seams which follow the convolutions of the heat exchange section.

A specific form of the present invention contemplates a heat exchange shell having convoluted walls in its heat exchange section with the convolutions tracing a generally sinuous pattern. The shell is formed of complementary half shells seamed around peripheral flanges of the half shells, with the seam in the intermediate heat exchange section being offset from a plane which bisects the shell's combustion chamber and flue gas collector in such a manner that no portion of any convolution in either shell half passes on the side of the seam occupied by the complementary shell half.

The flue gas collector is disposed immediately above the convoluted intermediate heat exchange section for receiving products of combustion from the section. The flue gas collector has an opening in the front of the shell for the discharge of products of combustion into a flue.

The combustion chamber is at the bottom of the intermediate heat exchange section and provides room for a burner and space for aspirating primary and secondary air used in combustion and which enter the chamber through an opening in its front. The combustion chamber opens into the intermediate heat exchange section for the discharge of products of combustion into it. The combustion chamber may have a plurality of vertically disposed stiffening ribs drawn in them to prevent oil canning.

The intermediate heat exchange section may have a cross section facing ascending combustion product

flow which progressively narrows from the combustion chamber to the flue gas collector to compensate for the increase in specific gravity of ascending gases as heat energy is removed from them. Stated in different words, it is desirable to provide for constant velocity in gas flowing through the heat exchange section, and progressively narrowing the cross section in the intermediate heat exchange section from the combustion chamber to the flue gas collector accomplishes this end.

In the intermediate heat exchange section immediately adjacent the opening into the combustion chamber, the convolutions are made such that flame impingement on either one of the walls of the heat exchange shell halves is avoided to avoid problems which would occur if the extremely hot flame from the combustion chamber impinged on a metal surface. In the area where the convoluted walls of each shell half bend towards each other to meet at the offset seam, it is preferred to have a diminishing bend radii.

To accommodate mounting of side-by-side shells, while providing air passages between mounted shells, it is preferred to have the mouths of the combustion chamber wider than the balance of the heat exchange shell so that adjacent shells' mouths can abut together.

The curvature of the convolutions in the intermediate heat exchange section beginning at the combustion chamber end of the section has the wall of one shell with a concave inward curvature and with a relatively large radius of curvature. The complementary facing wall of the other half shell is curved convexly inward and has a radius of curvature which is smaller than the wall of the half shell it faces. The result is an essentially straight path for ascending products of combustion from the combustion chamber for a distance along the wall whose curvature is concave inward, while a gradually constricting path is presented to such ascending gases by the wall whose curvature is convex inward. The predominant cross section facing ascending products of combustion is established well above the combustion chamber, this predominant passage being relatively constricted. The elevation above the combustion chamber at which the predominant cross section begins is sufficient to avoid impinge-ment of the heat exchange section wall by flame and very hot combustion gases. Heating of the walls of the more constricted sections of the heat exchange section will not cause their thermal fatigue and failure.

In the preferred construction of the present invention the half shell having the long concave, inwardly facing wall curves relatively rapidly inward toward the flange of the offset seam to touch the seam line and to then curve away from it. This wall continues with a curvature reversal to concave inward until just below the gas collector. The wall of the complementary heat exchange shell has a curvature which is essentially in phase with the curvature just described.

These and other features, aspects and advantages of the present invention will become more apparent from the following description, appended claims and drawings.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1** is an elevational side view of a preferred form of the heat exchange shell of the present invention;

FIG. **2** is an elevational front view of the heat exchange shell depicted in FIG. **1** looking inwardly into the combustion chamber and the flue gas collector;

FIG. **3** is a half-sectional, partial view taken along line **3—3** of FIG. **1** to illustrate the general configuration of the combustion chamber of the heat exchange shell by an illustration of one half of the combustion chamber;

FIG. **4** is a view taken along line **4—4** of FIG. **1**, but foreshortened, to illustrate the relative cross-sectional area of the gas passage in the heat exchange section at the rear and the front of the section proximate the combustion chamber;

FIG. **5** is a view taken along line **5—5** of FIG. **1**, but foreshortened to illustrate the cross-sectional area of the gas passage close to the flue collector; and

FIG. **6** is a view taken along line **6—6** of FIG. **2** to illustrate the curvature of the heat exchange shell from full passage width to the seaming weld flange.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. **1** and **2** illustrate a heat exchange shell **10** in accordance with the present invention. In general the shell is comprised of two half shells **12** and **14** secured together by welding peripheral flanges **16** and **18**, respectively, into a seam **19.** The heat exchange shell includes a combustion chamber **20,** a heat exchanger section **22** above the combustion chamber, and a flue gas collector **24** above the heat exchange section. The combustion chamber opens into the heat exchange section and the heat exchange section opens into the flue gas collector, both through openings extending essentially the depth of the heat exchange shell.

A burner, as for natural gas, is disposed in combustion chamber **20** when the heat exchange shell is used in a furnace. Products of combustion from the burning of air and fuel are drawn from combustion chamber **20** through heat exchange section **22,** collected in flue gas collector **24,** and discharged through a flue gas collector duct outlet **26.** Air for combustion is drawn into combustion chamber **20** through a combustion chamber inlet **28.** The products of combustion ascending through intermediate heat exchange section **22** heat the walls of the section, which in turn heat air circulated on the outside of the heat exchange shell. This air is usually circulated by a blower of the furnace into the spaces being heated.

Heat exchange section **22** has a pair of convoluted walls in a sinuous pattern to present a relatively large area for heat exchange between combustion gases and air in a relatively low height. The convoluted configuration of the heat exchange section also facilitates heat transfer by promoting scrubbing of the passage walls by ascending products of combustion on the inside of the shell and by air on the outside of the shell.

Heat exchange shell **10** is preferably fabricated by individual drawings of heat exchange shell halves **12** and **14.** This is done by a technique well known in the art. Suffice it to say here that the operation is effected through dies and punches. In the operation, it is highly desirable to stress the metal being worked in one direction only, in this case, tension. While it is possible to draw parts so that both tension and compression in the parts occur, the requirement often complicates tool design and, in addition, can result in an inferior or inadequate product. Another consideration in drawn parts is

not to draw the metal being worked too much. Excessive stretching of the parts material can lead to failure or unacceptable highly stressed parts.

The present invention provides a heat exchange shell which does not require excessive drawing and which avoids the requirement for both stretching and compressing metal during the fabrication of the individual shell halves. The resultant heat exchange shell is readily put together, for the welding flange geometry is simple. Moreover, because the metal is not excessively worked, drawing stresses do not create a reliability problem.

The present invention effects the ends indicated above by providing offset weld flanges **30** and **32** for half shells **12** and **14**, respectively, in heat exchange section **22**. The offset flanges illustrated in FIGS. **1** and **2** are primarily and most clearly illustrated with reference to the flanges at the front of the heat exchange shell. However, the welding flanges for the half shells at the rear of the heat exchange shell are essentially identical and will not, therefore, be described.

With specific reference to FIG. **2**, offset flanges **30** and **32** being slightly to the rear of the mouth of combustion chamber **20** just on each side of the medial plane bisecting the combustion chamber and the flue gas collector duct. The medial plane is shown in phantom and indicated by reference numeral **33**. The flanges then curve away from the medial plane to the right in the Figure for a distance, whereupon the flanges straighten for a distance before they curve gradually back to the medial bisecting plane. Where the flanges appear straight, they are substantially parallel to the medial plane laterally to one side of it. It will be noted that the wall of heat exchange half shell **12** in the intermediate heat exchange section never passes flange **30**, that is, it always remains on the left side of the flange or merges with it. Similarly, the wall of the intermediate section of the heat exchange section of half shell **14** never passes flange **32**, that is, it stays to the right or merges with flange **32**. This means that no wall material in the heat exchange section is drawn past the flange line, and as a consequence where the wall of the shell halves curves from full product of combustion passage width to meet the flanges (see FIG. **6**) there is no requirement for compression of wall material.

Viewed in a different light, it will be noted that the wall of half shell **12** in heat exchange section **22** passes through medial plane **33** bisecting combustion chamber **20** and flue gas collector **26** four times. The flange or seam line is displaced so that this does not happen.

With continued reference to FIG. **2**, a lower wall **34** of the heat exchange section of half shell **14**, meets combustion chamber **20** and extends almost planar upwardly toward flue gas collector duct **24**. The wall does have a curvature, which curvature is concave inward, but the radius of curvature is very large. Wall **34** meets an intermediate section of the wall **36** which has a radius of curvature substantially smaller than wall **34** and the curvature is oppositely directed, that is, the curvature of intermediate wall **36** is convex inwardly. Wall **36** at one point is tangent to flange **32**. Wall **36** continues upwardly to meet an upper wall **38**, which has a curvature opposite that of wall **36**, that is, it is concave inward. Thus the wall of heat exchange half shell **14** in the heat exchange section has a convoluted or serpentine shape, which is generally sinuous with three reversals of curvature, the third reversal of curvature being just before the entrance to the flue gas collector duct.

The curvature of the wall of heat exchange half shell **12** in the heat exchange section generally complements the curvature of the wall of heat exchange half shell **14** except in the vicinity of the combustion chamber **20**. In the vicinity of combustion chamber **20** a lower wall **40** has a concave, inward curvature which has a radius of curvature much smaller than the radius of curvature of lower wall **34**. As a consequence, the combustion product passage in the intermediate heat exchange section proximate the combustion chamber narrows rather rapidly in a direction away from the combustion chamber. The dominant combustion products passage geometry is established at about point **42** where lower wall **40** reverses its curvature and is tangent to welding flange **30**. At this point the combustion products passage is relatively narrow. The curvature of lower wall **40** is now convex inward. This curvature maintains itself for a slight distance towards flue gas collector **24** until intermediate wall **44** of half shell **12** is met, whereupon the curvature of the wall is concave inward. This curvature is maintained until upper wall **46** is reached where the curvature once again becomes convex inward. Wall **46** merges into flange **30** but does not pass it. Wall **46** progresses upwardly to meet the flue gas collector with another change of curvature. An important point to bear in mind here is that the curvatures of the walls of both sides in the intermediate heat exchange section of both shell halves are generally in phase. However, at the portion of the intermediate heat exchange section proximate the combustion chamber the passage is relatively wide to avoid flame impingement on the walls which would otherwise create combustion and thermal fatigue problems.

It is preferred that the cross-sectional area of the passage in intermediate heat exchange section **22** progressively diminishes as flue gas collector **24** is approached. As is well known, this feature compensates for the cooling of the ascending products of combustion and the concomitant reduction in specific volume. The compensation attempts to maintain the velocity of gas ascending through the intermediate heat exchange section roughly constant.

In FIG. **2**, the offset flanges appear straight between the points where they are shown obviously bending away from bisecting medial plane **33**. A slight degree of curvature here, however, is preferred.

Combustion chamber **20** may have a cutout **48** for a flame carry-over tube between adjacently mounted heat exchange shells. As is clear from FIG. **3**, combustion chamber **20** is relatively wide at the front of the heat exchange shell, then it necks down at about **50** to provide passage for air outside the shells. Thus, there is an expanded section **52** and a relatively narrower section **54** of the combustion chamber. In an assembly of two or more heat exchange shells **10**, adjacent shells would have their expanded sections side by side and in engagement with each other. The combustion chamber walls may be provided with ribs **56** to stiffen the walls of the combustion chamber for control of the direction of thermal expansion.

As shown in FIG. **2**, immediately above combustion chamber **20** there is a narrowing of the cross-sectional area of the products of combustion passage into the heat exchange section from that present for the prod-

ucts of combustion within the combustion chamber proper.

With reference to FIG. 5, the foreshortened view taken along line 5—5 of FIG. 1 depicts the relatively narrow cross-sectional area at this point of the product of combustion passage within heat exchange section 22. Relative to a line between the welding flanges, upper wall 38 of shell half 12 and upper wall 46 of shell half 14, which together define the heat exchange passage in the upper reaches of heat exchange section 22, are again asymmetrical.

With reference to FIG. 6, there is shown the curvature from the portion of heat exchange section 22 at the elevation of the section line from maximum product passage width to the welding flange. Specifically, wall 38 of shell half 14 bends rapidly to meet welding flange 32. In FIG. 6, wall 46 of shell half 12 is shown coplanar and merged with welding flange 30 along the line of the Figure's section.

The present invention has been described with reference to a certain preferred embodiment. The spirit and scope of the appended claims should not, however, necessarily be limited to the foregoing description.

What is claimed is:

1. An improvement in a heat exchange shell of the type formed of complementary first and second half shells joined together, respectively, along first and and second marginal edges thereof which circumscribe and generally divide a combustion chamber, a convoluted heat exchange section opening into the combustion chamber and defining a passage for products of combustion, and a flue gas collector opening into the convoluted heat exchange section, the improvement comprising:

the marginal edges of the shell halves in the heat exchange section being laterally offset from a medial, bisecting plane through the flue gas collector and the combustion chamber;

the laterally offset marginal edges in the heat exchange section extending substantially parallel to the medial plane; and

the convoluted walls of the first and second shell halves always being on opposite sides of an imaginary surface between the marginal edges in the heat exchange section.

2. The improvement claimed in claim 1 wherein:

the marginal edges in the heat exchange section begin at the combustion chamber and the flue gas collector on opposite sides of the medial plane, curve outwardly to the offset position, and then extend essentially parallel to the medial plane in the elevational middle of the heat exchange section.

3. The improvement claimed in claim 2 wherein the convoluted wall of the first shell half passes through the medial plane at least four times.

4. The improvement claimed in claim 3 wherein the convoluted walls of the heat exchange section progressively converge from the combustion chamber to the flue gas collector to progressively decrease the cross-sectional area of the passage for products of combustion and maintain the velocity of ascending products of combustion substantially constant.

5. The improvement claimed in claim 2 wherein the marginal edges are defined by welding flanges welded together to form a seam.

6. The improvement claimed in claim 5 wherein the convolutions in the heat exchange section are essentially sinuous with the convolutions of the first shell half generally in phase with the convolutions of the second shell half.

7. The improvement claimed in claim 5 wherein the passage for products of combustion is relatively wide proximate the combustion chamber in comparison to the balance of the passage to avoid excessive impingement by ascending products of combustion and flame.

8. An improvement in a heat exchange shell of the type used in home furnaces and having a flue gas collector, a heat exchange section having convoluted walls defining a passage for products of combustion, the heat exchange section being below and opening in to the flue gas collector, a combustion chamber below and opening into the heat exchange section, and a medial plane which bisects the flue gas collector and the combustion chamber, the shell being formed of a first and a second shell half with each shell half including portions of the flue gas collector, heat exchange section and combustion chamber, the first and second shell halves being secured together, respectively, around first and second marginal edges thereof, the improvement comprising:

the marginal edges of the first and second shell halves in the heat exchange section being laterally offset from the medial plane; and

the laterally offset marginal edges in the heat exchange section extending substantially parallel to the medial plane.

9. The improvement claimed in claim 8 wherein in the heat exchange section the convoluted wall of the first shell half passes through the medial plane and the convoluted wall of the second shell half is always laterally offset from the medial plane.

10. The improvement claimed in claim 9 wherein:

the marginal edges in the heat exchange section for the first and second shell halves begin at the combustion chamber and the flue gas collector on respective sides of the medial plane.

11. The improvement claimed in claim 10 wherein:

the marginal edges of both shell halves in the heat exchange section are welding flanges welded together to form a seam.

12. The improvement claimed in claim 11 wherein:

a. the second half shell wall in the heat exchange section includes:

i. a first portion beginning at the combustion chamber, curving inward towards the medial plane with a relatively large radius of curvature, and extending away from the combustion chamber towards the flue gas collector for a distance sufficient to avoid substantial impingement by hot products of combustion and combustion flame;

ii. a second portion above and joining the first portion which curves inwardly toward the medial plane to merge with its welding flange, the radius of curvature of the second portion being relatively smaller than the radius of curvature of the first portion; and

iii. a third portion above and joining the second portion which curves outwardly away from the medial plane and then curves inwardly to meet the flue gas collector, the radius of curvature of the third portion being less than that of the first portion; and

b. in the heat exchange section the first half shell wall is generally in phase with the second half shell wall.

13. The improvement claimed in claim **12** wherein:

the first half shell wall in the heat exchange section merges into its flange on each elevational side of the wall of the second half shell where the latter merges into its flange and wherein the flanges extend substantially parallel to the medial plane.

14. The improvement claimed in claim **13** wherein:

the first half shell wall in the heat exchange section begins at the combustion chamber with a concave inward curvature with a smaller radius of curvature than the corresponding wall of the second half shell which it faces to gradually approach such corresponding wall and narrow the product of combustion passage until a predominant, relatively narrow products of combustion passage is met proximate the closest to the combustion chamber merger of the first half shell wall in its flange.

15. The improvement claimed in claim **14** wherein the predominant, relatively narrow products of combustion passage progressively narrows in the direction of the flue gas collector until it opens into the flue gas collector to maintain the velocity of products of combustion in the predominant portion of the products of combustion passage substantially constant.

* * * * *

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,807,382 Dated April 30, 1974

Inventor(s) Waldron Nathaniel Kennedy

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In the specification: Column 3, line 46, "impinge-ment" should be --impingement--. Column 5, line 22, "being" should be --begin--.

In the claims: Claim 8, column 8, line 14 "in to" should be --into--.

Signed and sealed this 29th day of October 1974.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents