Oct. 14, 1952 K. H. FLINT 2,613,920

HEAT EXCHANGER

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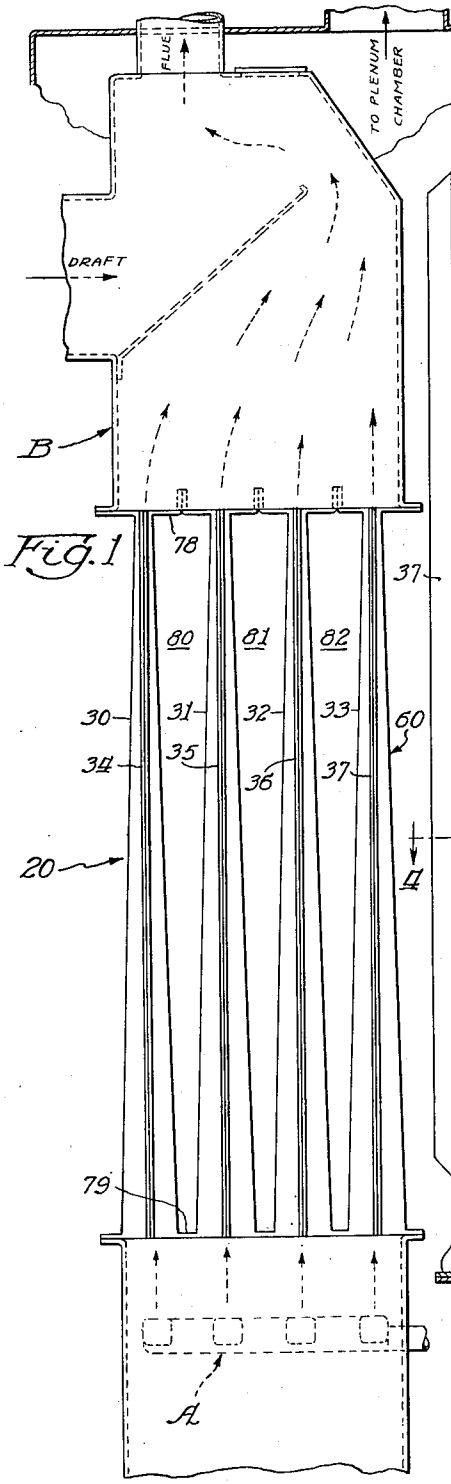
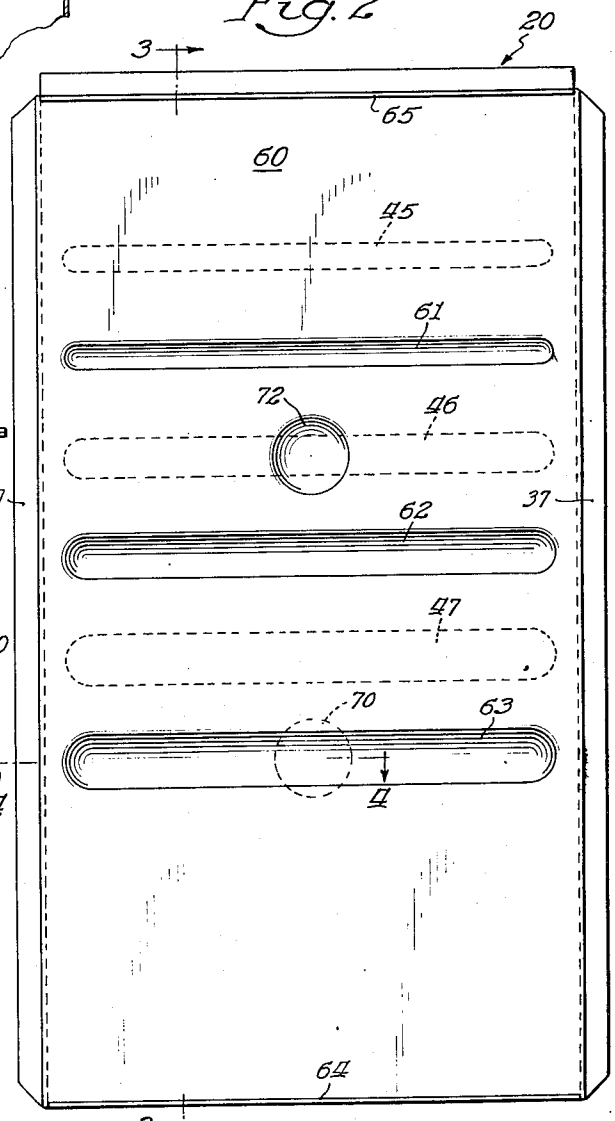


Fig. 1

Fig. 2



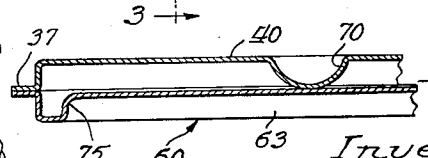


Fig. 4

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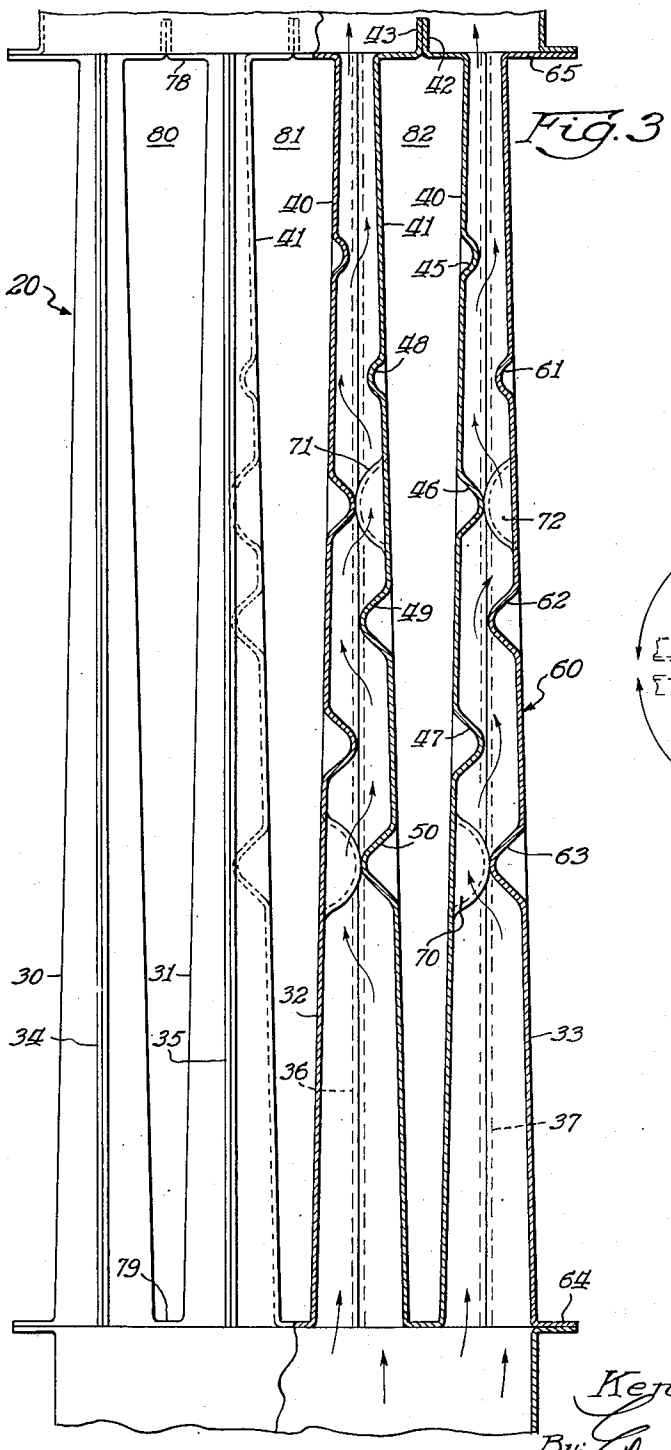


Fig. 3

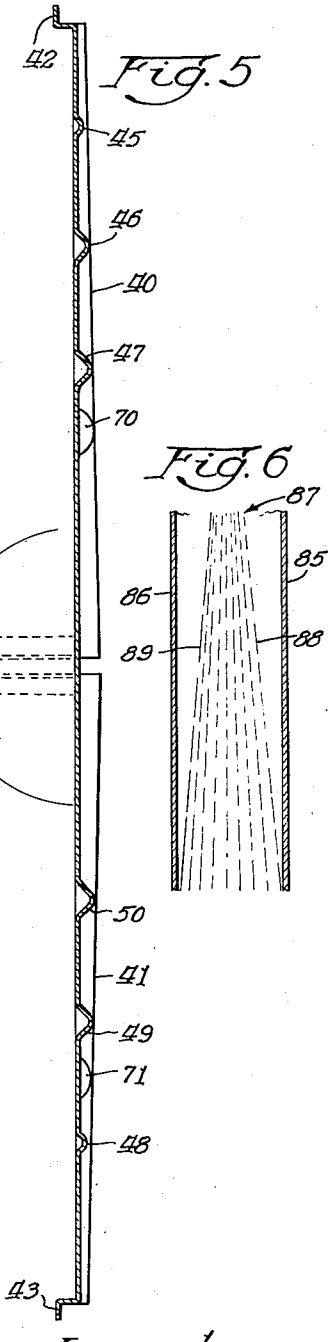


Fig. 5

Fig. 6

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HEAT EXCHANGER

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6 Claims. (Cl. 257—174)

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This invention relates in general to improvements in air heating furnaces, and it has particular reference to the provision of an improved heat exchanger and its organization in air heating furnaces in such manner that the maximum efficiency of the products of combustion will be attained.

Heretofore, in earlier prior art air heating furnace constructions the heat exchangers were formed of cast iron or the like which obviously was an expensive construction. With the advent of formed steel, many of the disadvantages of the cast type heat exchanger were overcome because new shapes heretofore found impossible were formed to increase the efficiency of the heat exchangers. It has long been recognized that one of the very important factors in the construction of a proper heat exchanger is that of maintaining the products of combustion within the heat exchanger as long as possible and also to provide an even and effective distribution of heat through the entire heat exchange surfaces of the heat exchanger.

In order to accomplish and give proper consideration to the aforementioned important factors, prior art constructions defined many different shapes providing serpentine passageways, fluted formations, baffles, and the like, each being of expensive construction and, although increasing the efficiency of the heat exchanger to a degree, were deficient in obtaining the maximum exchange of heat between the products of combustion and the heat exchange surfaces of the heat exchanger.

It is recognized that in the prior art numerous attempts have been made to provide a heat exchanger of this general class and efforts have been made to overcome the various deficiencies found in such prior art structures, but to the best of the applicant's knowledge the prior art structures have had only limited success and have been accorded only limited commercial recognition. It is believed that this fact results from apparent deficiencies of the prior art structures, their nonadaptability for universal application and their expensive construction which so greatly increased the cost as to seriously handicap sales acceptance.

The present improvements in heat exchangers are directed to simplify their construction and their mode of operation, and also to provide a heat exchanger which may readily and conveniently be employed universally to various types and sizes of air heating furnaces presently being commercially exploited. Moreover, the present

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device seeks to employ conventional parts wherever necessary and possible, thereby to effect a further substantial reduction in the cost over the prevailing types of heat exchangers presently being employed.

According to one aspect of the present invention the desired result may be obtained by utilizing a heat exchanger formed of steel to define chambers through which products of combustion may advantageously flow, said chambers being particularly characterized in that the side walls thereof are tapered so that the top opening is smaller than the bottom inlet opening and said side walls being provided with indentations arranged in a manner so that the products of combustion flowing through the chamber will define a serpentine path, thereby to increase the tendency toward a "scrubbing action" between the products of combustion and the side walls of the heat exchanger.

Accordingly, an object and accomplishment of the invention is to provide a heat exchanger formed of welded steel to define a plurality of chambers having upwardly tapering side walls, thereby progressively reducing the area inside the flue chamber, whereby there is maintained a constant density of gases under a reducing flue temperature and, therefore, more molecules come in contact with the heating surfaces than would come in contact in a straight flue, the invention being particularly characterized in that the products of combustion passing through the chamber will actually define a tapered path comparable to that defined by the upwardly tapering side walls of the chamber as taught by this invention, thereby obtaining a "scrubbing action" between the products of combustion and the upwardly tapering side walls of the chamber at a point where there will be the greatest exchange of heat between these elements.

Another object and accomplishment of the invention is to provide an improved heat exchanger as contemplated herein and which may be manufactured in segments, thereby to increase the versatility of the assembled heat exchanger in that various sizes and arrangements may be attained to facilitate universal application of the teachings of this invention.

Another object and accomplishment of the invention is to provide an improved heat exchanger by co-relating and especially designing the various elements thereof, whereby there shall be such cooperation between said improved elements as will best serve the purpose of providing an efficient heat exchanger capable of being manu-

factured at low cost and yet giving maximum of satisfactory service in use.

The invention seeks, as a further object and accomplishment, to provide a heat exchanger and an arrangement thereof as contemplated herein and particularly characterized by an arrangement of parts to more advantageously and satisfactorily perform the functions required of it and adapted to provide a compact unit which will successfully combine the factors of structural simplicity and durability, and yet be economical to manufacture.

A further object and accomplishment of the invention is to provide a new and improved form of heat exchanger which is adapted to be economically manufactured, and which is so designed as to permit the manufacture and assembly thereof, in accordance with present day large scale mass production manufacturing methods of construction and assembly.

Additional objects, features and advantages of the invention disclosed herein will be apparent to persons skilled in the art after the construction and operation are understood from the within description.

It is preferred to accomplish the various objects of the invention and to practice the same in substantially the manner as hereinafter more fully described, and, as more particularly pointed out in the appended claims.

With the above and other incidental objects in view, the invention has other marked improvements and superiorities which radically distinguish it from presently known structures, these improvements in the invention residing in the novel construction and cooperative function of the parts thereof, the combination of the parts and the arrangement thereof as illustrated in the drawing and which will be more fully described hereinafter and particularly pointed out in the claims.

In the accompanying drawing on which there is shown a preferred embodiment of the invention,

Fig. 1 is a side elevational view of a heat exchanger assembly embodying the features of the present invention;

Fig. 2 is an elevational view of the heat exchanger depicted in Fig. 1;

Fig. 3 is an elevational view of the heat exchanger depicted in Fig. 2 and having portions thereof shown in section taken substantially on the plane of the line **3—3** in Fig. 2 in order to clearly illustrate the construction thereof;

Fig. 4 is a sectional view of a portion of the heat exchanger depicted in Fig. 2 and being taken substantially on the plane of line **4—4** in Fig. 2;

Fig. 5 is a sectional view of one element of the heat exchanger depicted in Figs. 1 and 2 and illustrating the opened position of said element or flat shallow substantially U-shaped channel configuration after formation from a flat steel blank and before being bent into shape i. e., in a substantially U-shaped configuration to define one element of the heat exchanger as depicted in Fig. 3; and

Fig. 6 diagrammatically illustrates the theoretical aspects relating to the tapered flue construction forming an important feature of the present invention.

The drawings are to be understood to be more or less of a schematic character for the purpose of illustrating and disclosing a typical or preferred form of the improvements contemplated herein, and in the drawings like reference characters identify the same parts in the several views.

As one possible example of advantageous employment of the heat exchanger and the arrangement thereof, reference is made to the drawings, particularly Fig. 1, wherein there is illustrated the heat exchanger with which the present invention is particularly concerned and designated in its entirety by the numeral **20** as being operatively associated, for example, with a heating apparatus supplied with a fluid fuel, such as gas, emanating from gas jets or burners designated in their entirety by the letter A, and a collection box designated in its entirety by the letter B and disposed above said heat exchanger **20** in a position to receive the expanded products of combustion from the heat exchanger per se, thereby to distribute the same to a suitable flue.

The gas burners A may be of conventional construction and arranged so that each segment of the heat exchanger **20** will have operatively disposed therebelow one unit of said gas burners in a manner so that the products of combustion will be received into the element.

Suffice it to say, since the invention is not particularly concerned with the precise construction of the gas burners and the other associated parts of the air heating furnace, they will not be further described in detail, and it is deemed sufficient for all intentions and purposes herein contained to show only portions thereof adjacent to and cooperating with the heat exchanger and the arrangement thereof as contemplated herein. It is to be understood that details of construction of such air heating furnaces with which the heat exchanger arrangement contemplated herein may advantageously be employed, and/or their associated parts, may be modified to suit particular conditions or to satisfy the engineering genius of various manufacturers, and I do not wish to be limited to the precise construction of these elements as set forth except where such construction particularly concerns the invention contemplated herein.

Having thus described, by way of example, a possible adaptation of the heat exchanger and the arrangement thereof generally indicated at **20** and as contemplated herein, and having described the general environment surrounding the adaptation, the specific construction and cooperative functions of the parts of said heat exchanger with which the present invention is particularly concerned, will now be described in detail.

Referring now to the drawings, it will be observed from the side views shown in Figs. 1 and 3 that I have illustrated a four-section heater, but I wish it to be understood that while the multiplication of similar units for the production of a multiple section heater is an important feature of the invention, so far as certain features of the invention are concerned, the heater may consist of a single section and that the multiple section heater may be composed of two sections, three sections, four sections as herein illustrated, or more if desired.

In the exemplary embodiment of the invention depicted in Figs. 1, 2, 3, 4, and 5, the heat exchanger **20** with which the present invention is particularly concerned comprises, in general, a series of upstanding tubes **30, 31, 32** and **33** formed of pressed steel elements and respectively having flanges **34, 35, 36, 37** which are welded by any suitable approved practice to secure these elements to define the shape as shown.

Since all of the tubes are of similar construction it is deemed sufficient for all intentions and purposes herein contained to describe only two of them. Accordingly, particular attention is invited to the formation of the tubes **32** and **33**.

Adverting to Fig. 5 it can be seen that the elements forming a part of the heat exchanger **20** are formed in separate units or substantially U-shaped channels which are relatively shallow and relatively wide from a flat steel blank to define the shape as illustrated in Fig. 5. After the formation of the unit or channel, the legs **40** and **41** are bent in the direction of the arrows, that is, the channel is bent back on itself in a U-shaped manner to substantially define a U-shaped configuration to a position indicated by the dotted lines and so that the end portions or flanges **42** and **43** respectively of the legs **40** and **41** engage each other and are welded to define a unit of the heat exchanger **20**.

It can be seen that the leg **40** is deformed to provide a plurality of inwardly extending indentations **45**, **46**, and **47** while the leg **41** is also deformed to provide a plurality of inwardly extending indentations **48**, **49** and **50**. These indentations, as clearly shown in the drawing, substantially meet the center line of the tube and provide an interruption to the upwardly flowing combustion gases while passing through the tubes in order to effectively and advantageously provide a more efficient "scrubbing action" between the combustion gases and the heat exchange surfaces. This serpentine passage of the combustion gases through the tubes is defined by the arrows depicted in Fig. 3, and can readily be seen to be provided within the tube by the successive alternation of the indentations on both walls of the tube so as to be spaced from the opposing wall.

Having thus described one unit of the heat exchanger **20**, particular attention is invited to Figs. 3 and 5 which illustrate that it is necessary to have an end member, generally indicated by the numeral **60**, which actually is one-half of a unit as disclosed in Fig. 5 and more particularly defines a shape similar to that of the leg **41**. Thus it can be seen that the end member **60** is also deformed to define a plurality of indentations **61**, **62** and **63**. Moreover, at each end of the end member **60**, there is provided flanges **64** and **65** which complete the structural definition of this element.

Again adverting to Fig. 3, it can be seen that an element of the heat exchanger **20**, as disclosed in Fig. 5 and when finally formed to assume its position as disclosed in Fig. 3, defines only one-half of the tube, it being necessary to assemble another like element in position to complete the tube formation. Accordingly, in Fig. 3, the leg **40** defines only one-half of the tube **33** while the end member, when placed in position as disclosed in Fig. 3, will complete the formation of the tube **33**.

In order to provide proper spacing between the various units of the heat exchanger **20**, there are provided spacers **70**, **71** and **72**, each being a cup-like deformation extending inwardly of the walls of their respectively associated legs. In Fig. 3, in connection with the tube **33**, it can be seen that the spacer **70** is arranged to engage the indentation **63** and thus substantially meet the center line of the tube while the spacer **72** forming a part of the end member **60** is arranged to engage portions of the indentation **46** forming a part of the leg **40**. This construction is more clearly illustrated in Fig. 4 wherein the lateral extent of the indentations is illustrated. It can be seen that the indentations are stopped short at the ends of the units as indicated at **75**. The spacers are cup-like shaped in order to permit the combustion gases to pass through the tubes in their defined paths to the top of the tubes.

When the units of the heat exchanger are welded in their operative positions as illustrated in Fig. 3, it can be seen that the flanges disposed at the top and the bottom of the heat exchanger units define a top wall **78** and a bottom wall **79**, thereby sealing off the flow of the combustion gases so that these combustion gases emanating from the heat elements A will flow through the tubes and up to the collection box B. A further purpose of the top wall **78** and the bottom wall **79** is to provide air chambers **80**, **81** and **82** through which flowing air may be forced in heat exchange relation with the heat exchanger thereby to heat said air to a desired temperature whereupon said air will be directed, via a plenum chamber and suitable ducts (not shown), to rooms which are desired to be heated.

Having thus described the general constructive features of the heat exchanger **20** as contemplated herein, the theoretical operation of the device will now be explained. Attention is invited to Fig. 6 which diagrammatically illustrates a conventional tube having parallel upstanding side walls **85** and **86**. It has been found that the density of combustion gases passing upwardly through a tube is proportional to the absolute temperature. It is obvious that the temperature at the lowermost portion of the tube will be higher than the temperature in the upper portion of the tube. Thus, by following this procedure it is also obvious that the density of the combustion gases will be greater at the lower portions of the tube and that the density of the combustion gases will be proportionally reduced as the temperature drops while the combustion gases move upwardly in the tube. Thus, by reducing the area inside the flue chamber by employment of the wedge-type flue of the instant invention there is maintained a constant density of gases under a reducing flue temperature and, therefore, more molecules come in contact with the heating surfaces than would come in contact in a straight flue. Accordingly, as illustrated in Fig. 6, the density of combustion gases will define approximately a tapered wedge-like shape as diagrammatically illustrated by the numeral **87**. Thus, it can be seen that the density, or, in other words, the hottest portion, of the combustion gases passing through the tube will be within the area defined by broken lines and designated by the numeral **87**. In this connection, it is also important to note that the hottest area would be within that portion defined by the lines **88** and **89**. Thus, it is obvious that if the walls **85** and **86** would be moved inwardly to define a tapered formation and respectively lie in the same planes as the lines **88** and **89**, the most efficient heat exchange would be accomplished. This, in theory, is the important feature of the subject invention.

Therefore, the combination of the upwardly tapering side walls of the respective units of the heat exchanger in combination with the functions of the indentations in the side walls of each of the units of the heat exchanger will substantially increase the heat exchange characteristics between the products of combustion and the side walls of the heat exchanger. Moreover, the indentations, in addition to the other features, provide an effective "scrubbing action" of the prod-

ucts of combustion with the side walls of the heat exchanger. Thus, it is apparent that a more uniform distribution of the heat is effected to the heat exchange surfaces. Therefore, when air is forced through the chambers 80, 81 and 82, the substantially even distribution of heat across the heat exchange surfaces of the respective units of the heat exchanger will substantially increase the exchange of heat to the air which obviously results in more efficient operation and saving in fuel costs.

The heat exchanger contemplated herein may be advantageously employed in mass production manufacturing methods. In this connection, the versatility of the heat exchanger in being capable of being manufactured in multiple units as desired to accommodate various sizes and shapes of furnaces will result in substantial economies of manufacture. In addition to this very important feature, the improved heat exchanger contemplated by this invention provides substantial increased efficiency of operation which will result in economies of operation.

From the foregoing disclosure, it can be observed that I have provided an improved heat exchanger which efficiently fulfills the objects thereof as hereinbefore set forth and provides numerous advantages which may be summarized as follows:

1. Structurally simple, efficient and durable;

2. Economical to manufacture and readily adaptable to mass production manufacturing principles; and

3. The provision of a heat exchanger which may be manufactured in any desired number of segments, thereby to increase the versatility of the assembled heat exchanger in that various sizes and arrangements may be obtained to facilitate universal application of the teachings of this invention.

While I have illustrated a preferred embodiment of my invention, many modifications may be made without departing from the spirit of the invention, and I do not wish to be limited to the precise details of construction set forth but wish to avail myself of all changes within the scope of the appended claims.

I claim:

1. A heat exchanger for a warm air furnace comprising, a plurality of upstanding tubes of substantially shallow flat rectangular contour with a pair of substantially flat walls and arranged in parallel spaced relation to each other for receiving the products of combustion from a heat source, said tubes being defined by a series of sections, each section comprising a substantially flat U-shaped channel configuration and being bent back on itself to define the legs of a second U-shaped configuration, one leg of said last mentioned U-shaped configuration forming one-half of the shallow rectangular tube and the other leg of said last mentioned U-shaped configuration forming one-half of the next adjacent shallow rectangular tube, said substantially flat walls having a plurality of indentations which substantially meet the center line of said tube and extend substantially transverse the width thereof, said indentations being spaced along both walls and successively alternated so as to be spaced from the opposing wall of the tube to provide a serpentine path in the tube for the products of combustion, the opposed walls of each tube being continuously tapered toward each other in an upward direction to provide a larger opening at the bottom than the top, and inward cupped-like deformations on the walls opposite the indentations of the same tube and in touching relationship with said indentations to provide spacers to hold said walls of the respective tubes in proper spaced relation.

2. A heat exchanger for a warm air furnace for receiving the products of combustion from a heat source comprising a series of sections being of flat channel shaped formation with a plurality of inward indentations extending substantially the depth of the region defined by the channels and substantially transverse the width of the channels, said channels being bent back on themselves in a U-shaped manner and placed adjacent each other so that two successive sections form walls of a tube open at its top and bottom ends, the opposing walls of said tubes being continuously tapered toward each other to provide a larger opening at one end than at the other, said indentations being spaced along one wall of the channel and successively alternated with respect to the indentation on the opposed wall so as to be spaced from the opposed wall of the other channel to provide a serpentine path in the tube for the products of combustion, and a plurality of cup-like inward deformations on the wall directly opposite the indentations, said deformations meeting the latter substantially at the center line of the tube to provide spacers to hold the walls of the respective tubes in proper position.

3. A heat exchanger for a warm air furnace for receiving the products of combustion from a heat source comprising a series of sections being of flat channel shaped formation with a plurality of inward indentations extending substantially the depth of the region defined by the channels and substantially transverse the width of the channel, said channels being bent back on themselves in a U-shaped manner and placed adjacent each other so that two successive sections form walls of a tube open at its top and bottom ends, the opposing walls of said tubes being continuously tapered toward each other to provide a larger opening at one end than at the other, said indentations being spaced along said walls and successively alternated so as to be spaced from the opposed wall of the other channel to provide a serpentine path in the tube for the products of combustion, a plurality of inward deformations on the wall directly opposite the indentations, said deformations meeting the latter substantially at the center line of the tube to provide spacers to hold the walls of the respective tubes in proper position, and flanges on one end of said bent back sections in abutting relation with each other to provide proper spacing between the respective tubes so as to define a closed fluid path for the products of combustion.

4. A heat exchanger for a warm air furnace for receiving the products of combustion from a heat source comprising a series of integrally formed substantially U-shape channel sections with a relatively wide wall and two relatively narrow walls formed at substantially right angles to said wide wall, said channel being bent back on itself to provide a U-shaped configuration and placed adjacent each other so that two successive sections define shallow tubes, the walls of one section forming one-half of one shallow tube and the walls of the other section forming one-half of the next adjacent shallow tube, said tubes being open at both ends, the opposing walls of each tube being continuously tapered toward each other to provide a larger opening at one end than at the other, a plurality of indentations

on the opposed side walls of each tube and extending transversely across the width of said walls, said indentations being in opposed staggered relationship so as to be spaced from the opposed wall of the tube and thereby providing a serpentine path for the products of combustion from the heat source entering said larger opening of the tube, and cupped-like deformations opposite said indentations, said cup-like deformations extending inwardly a depth so as to substantially meet the latter to provide spacers to hold the walls of the respective tubes in proper spaced relationship.

5. A heat exchanger as claimed in claim 4 wherein each of the bent back sections is provided at one end with bent back flanges in abutting relationship to provide proper spacing between the sections so as to define a closed fluid path for the products of combustion.

6. A heat exchanger for a warm air furnace comprising a series of sections secured together to define a plurality of upstanding flat tubes of rectangular contour open at the bottom and top and arranged in parallel spaced relation to each other for receiving the products of combustion from a heat source, each section being defined by a relatively shallow and relatively wide U-shaped channel being bent back on itself in a U-shaped manner and placed adjacent a similar section so that two successive sections define the tube, one-half of one section defining the walls of one-half of a first shallow tube and the other half of said section defining the walls of one-half of a second shallow tube, a plurality of indentations substantially transverse said side walls and extending inwardly of each tube wall, said indentations being spaced along the walls and successively alternated so as to be spaced from the walls of the opposed wall of said tube thereby providing a serpentine path in the tube for the products of combustion, the opposing walls of each tube being continuously tapered toward each other in an upward direction to provide a larger opening at the bottom than at the top, and cup-like deformations extending inwardly to meet some of said indentations to provide spacers to hold the walls of the respective tubes in proper position.

KENDALL H. FLINT.

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