Nov. 4, 1930. A. H. DAVIS, JR 1,780,294

HEAT EXCHANGING APPARATUS

Filed Feb. 1, 1929 3 Sheets-Sheet 1

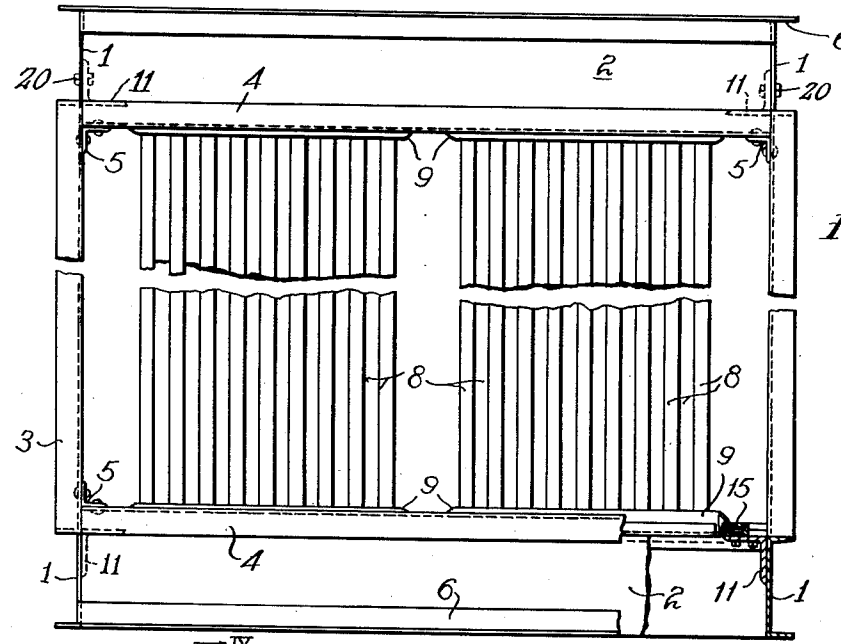


Fig. 2.

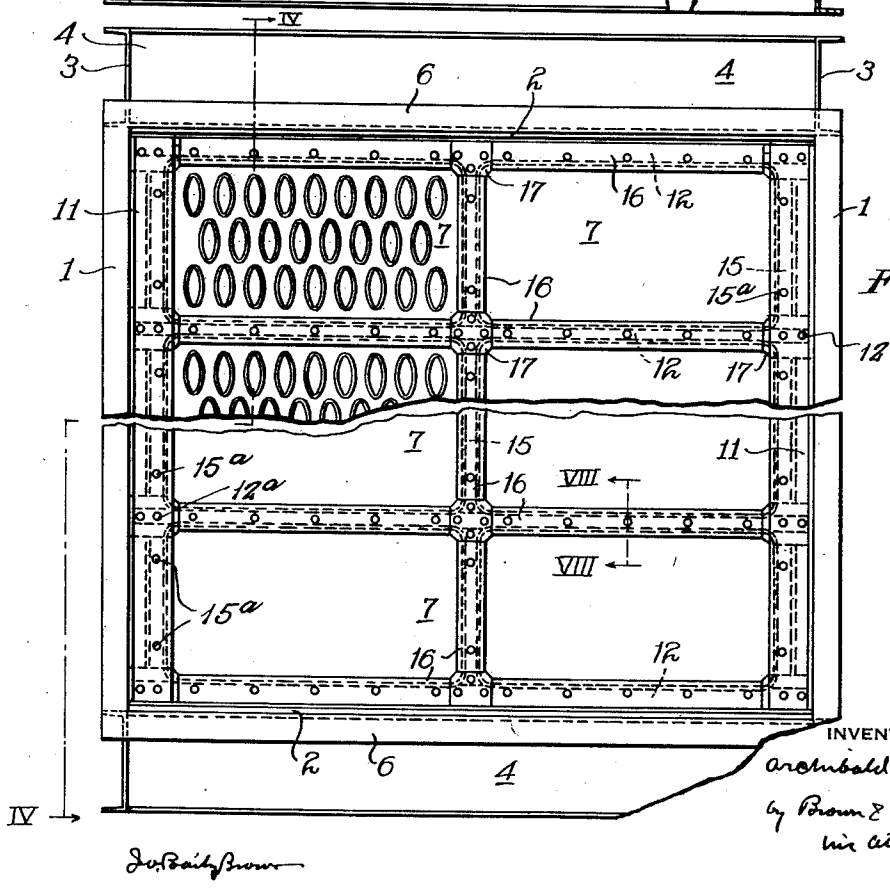


Fig. 1.

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Filed Feb. 1, 1929 3 Sheets-Sheet 2

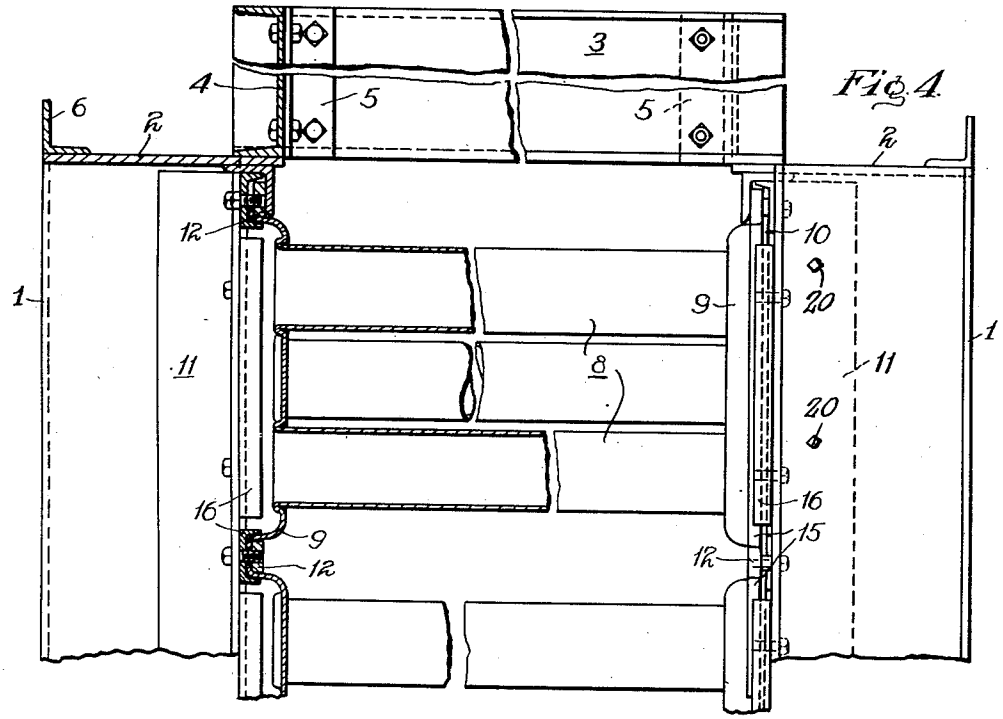


Fig. 4.

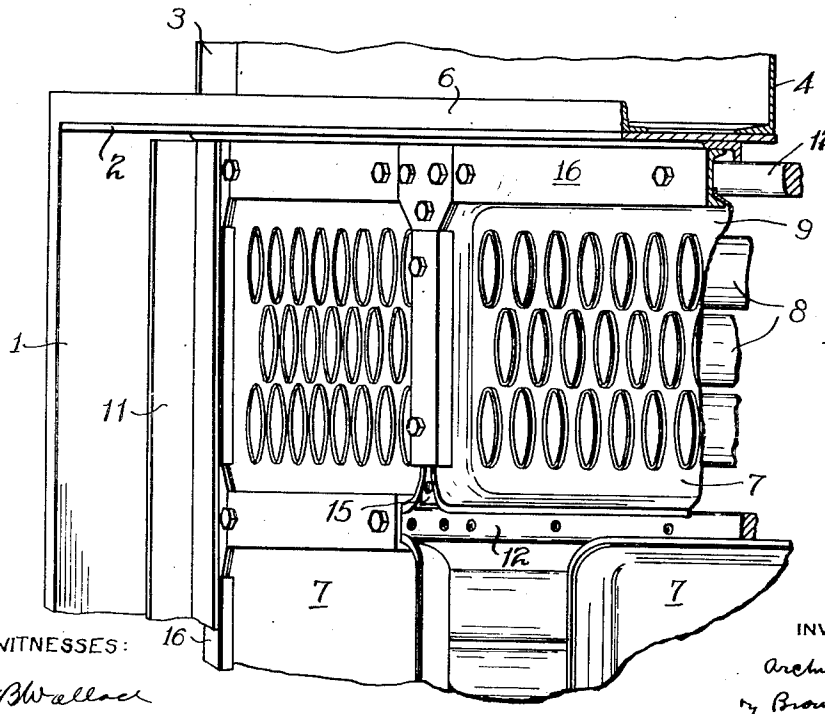


Fig. 3.

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HEAT EXCHANGING APPARATUS

Filed Feb. 1, 1929 3 Sheets-Sheet 3

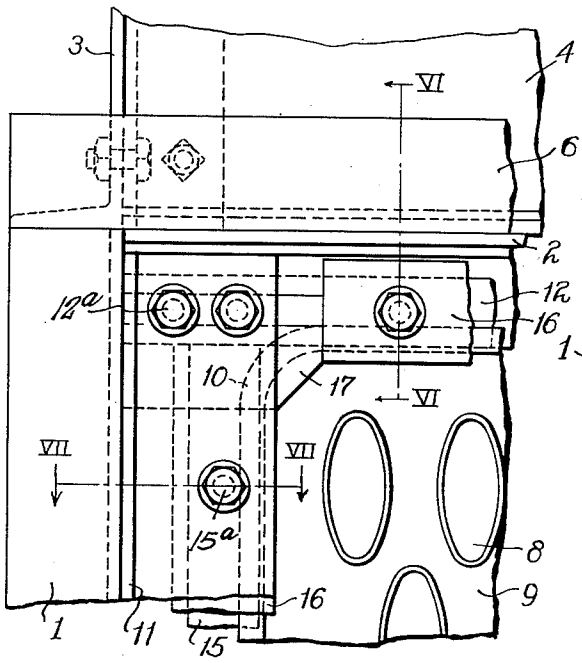


Fig. 5.

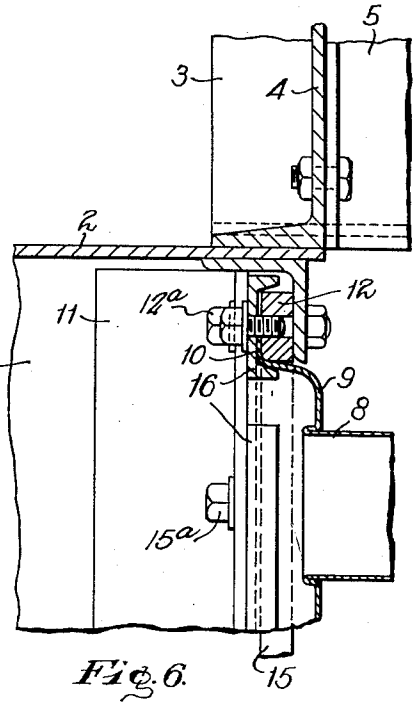


Fig. 6.

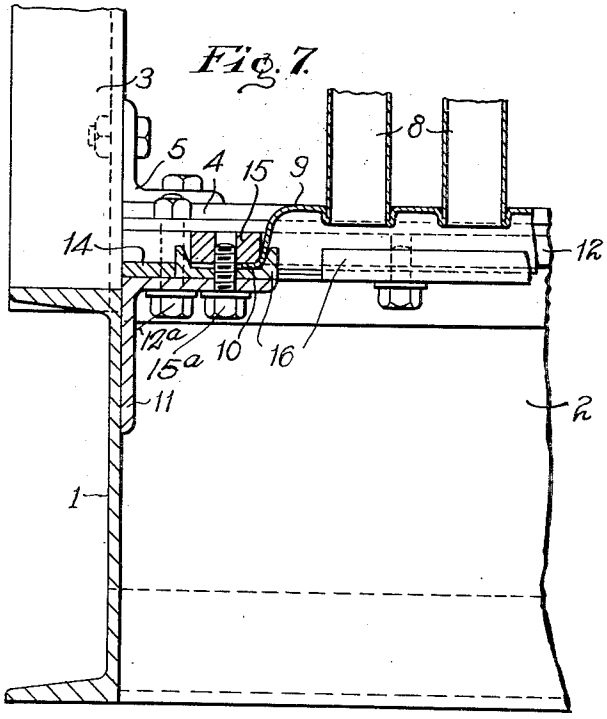


Fig. 7.

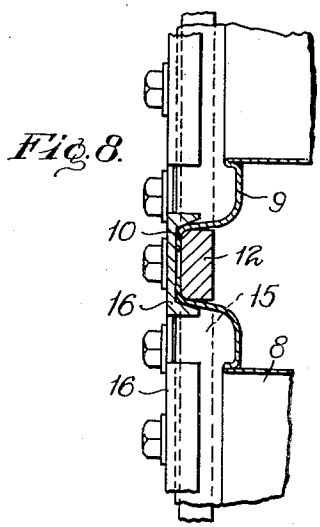


Fig. 8.

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UNITED STATES PATENT OFFICE

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HEAT-EXCHANGING APPARATUS

Application filed February 1, 1929. Serial No. 336,746.

This invention relates to heat exchanging apparatus and especially to apparatus for preheating air from hot waste gases.

Regenerative preheaters are bulky, expensive to install, and require mechanism for alternating gas and air flow. The reversing mechanism requires adjustment and attention, and, through faulty operation, it may cease to function, or do so improperly, thus disturbing operation of the units with which it is associated. Although compact, the plate type of heat exchanger is disadvantageous because replacement of the plates is difficult, soot accumulation may be high and its removal difficult. The most efficient heat transfer has been secured by means of tubular heat exchangers. These provide turbulent gas flow around the tubes, with decreased soot accumulation as compared to the other types, and such soot as deposits on the tubes may be removed easily. Tubular preheaters, however, are expensive because their construction is such that tubes must be individually installed or replaced in the headers, and in the latter case material disassembly is necessary and the replacement is slow. Also, the prior tubular heaters do not permit standardization, so that each installation is a separate job and the apparatus is not readily combinable to provide various sizes. Furthermore, their construction is usually such that expansion and contraction may cause serious stresses to be set up.

An object of the invention is to provide tubular heat exchanging apparatus which embodies all of the advantages and minimizes the disadvantages of prior tubular apparatus of this type, which is compact, of simple and relatively inexpensive construction, in which the tubes are grouped in standardized radiator units arranged sectionally to provide for easy removal of the individual units without material disassembly of the apparatus and which are readily combinable to give apparatuses of different sizes, and in which all removable parts are readily accessible.

Another object is to provide such heat exchanging apparatus in which the radiator units are built from tubes of generally elliptical cross section, to provide minimum deposition of soot, decrease resistance to gas flow, and provide more efficient heat transfer surface than has been present in heat exchanging apparatus using round tubes.

A further object is to provide apparatus of the type referred to which provides for differential expansion of the radiators and framework, and for expansion and contraction of the unitary tube headers.

The preferred embodiment of the invention is shown in the accompanying drawings, in which Fig. 1 is a front elevation; Fig. 2 is a plan view of the apparatus shown in Fig. 1; Fig. 3 is a fragmentary perspective view showing a radiator unit 7 (in the lower right hand corner) partly withdrawn; Fig. 4 is a partial side elevation and transverse section taken on line IV—IV, Fig. 1; Fig. 5 is an enlarged view of one of the corners of the apparatus shown in Fig. 1; Fig. 6 is a vertical section at a corner taken on line VI—VI, Fig. 5; Fig. 7 is a horizontal section through a corner taken on line VII—VII, Fig. 5; and Fig. 8 is an enlarged sectional view showing the manner of connecting the radiator units in the apparatus, taken on line VIII—VIII, Fig. 1.

Having reference to the drawings, the apparatus provided by the invention comprises a framework and superimposed radiator units each comprising a plurality of parallel heat exchanging tubes.

The frame is preferably built up from structural sections, as shown especially in Figs. 1 to 4. The apparatus shown comprises vertical side channels 1 to which connecting plates 2 disposed across their ends are joined in any suitable manner, as by welding. The top and bottom of the frame work are formed by longitudinal channels 3 and transverse channels 4 connected at their abutting ends by angles 5 bolted thereto. The channels 4 are preferably connected to plates 2 by welding. This structure provides an open box-like frame work, and air and gas ducts, not shown, may be readily connected to the opposed openings formed between channels 3 and 4 and between channels 1 and plate 2, the outer legs of the channels acting as flanges for

that purpose. To provide a continuous peripheral duct-connecting flange around the openings defined by channels 1 and plates 2, angles 6 are welded to the outer edges of the plates.

In accordance with the invention the heat exchanging tubes are grouped into a plurality of individual radiator units 7. A suitable number of these units are carried in the framework one above another, the construction being such as to render the units individually removable from the sides of the apparatus, that is to the right or left in Figs. 1 and 2. This provides a sectional construction, with the advantage attendant upon such structures.

The tubes may be of any suitable form, but it is preferred to use tubes having a flattened, generally elliptical cross section, because such tubes when disposed with the major axis of the section parallel to the direction of gas flow, offer less resistance to flow, decrease soot deposition and increase the effectiveness of soot blowers, as compared with round tubes. Furthermore, they can be placed closer together than round tubes, which makes the units more compact, causes the gas to scrub substantially the entire tube surface, and brings air or other media passed through the tubes into contact with a greater area of heat exchanging surface.

The radiator units may be constructed from tubes and headers in any desired manner, but in the preferred embodiment there are used radiators of the type disclosed in United States Patent No. 1,320,652 to C. Sonneborn, dated Nov. 4, 1919. According to that patent, the ends of oval tubes 8 are welded to pan-shaped headers 9 having an outwardly bent peripheral flange 10, Figs. 4 to 8. These headers are made by pressing sheet metal, and for ease of withdrawal from the dies, the sides of the pan are sloped from the bottom to the flange. As hereinafter described, this sloping construction is made use of in taking care of header expansion. This form of radiator possesses advantages of simple, sturdy, and relatively inexpensive construction, and there are no mechanical joints to loosen or otherwise cause trouble.

These radiator units are mounted in the framework one above another, to give sectional stacks from which any units may be laterally withdrawn when necessary. A single stack of units may be used, or as in the form shown, two or more stacks may be built up side by side.

In the embodiment shown in the drawings, the radiator units are supported as follows, this construction being applicable to both single and multiple stack apparatuses. Rail-supporting members 11, preferably angles, are disposed vertically on each side of two opposed openings, for connection to horizontal guide rails 12 spaced apart vertically to receive the radiator units 7, as shown particularly in Figs. 2 and 4. Members 11 are preferably disposed in the openings formed by channels 1 and plates 2, and the angles, which extend the full height of the opening, are placed with one arm against the web of the channel and the other arm projecting into the opening.

The radiator units are placed in the framework by insertion through the openings between channels 1—1 and 3—3 from the right or left of Figs. 1 and 2, the headers 9 and flanges 10 slidably engaging rails 12. A unit 7 partially withdrawn is shown in the lower right-hand portion of Fig. 3. In order to provide for ready withdrawal of the units past angles 11 and channels 1, the rails 12 are spaced from the angles by spacer blocks 14, as shown in the corner assembly of Fig. 7. Short sections 15 of rail are positioned vertically between adjacent horizontal rails 12 on each side of the headers, for use in locking the units in position. After the units have been set in place, they are connected to rails 12 and 15 by clamps 16 which engage adjacent edges of the headers of two contiguous units. These clamping members are preferably of channel form, the inner surfaces of their legs being tapered outwardly, as shown in Figs. 6 to 8. In the apparatus shown, the horizontal clamps and the central vertical clamps are bolted directly to the rails. The vertical clamps at the side of the apparatus are bolted to rails 15 by bolts 15^a engaging both the angles 11 and the clamps. Horizontal rails 12 are connected to angles 11 by bolts 12^a. To remove a unit, bolts 15^a are taken out from its outer side clamp 16, and the center side clamp and horizontal clamps are disconnected, leaving rails 12 supported by bolts 12^a.

It is desirable to provide means for permitting free expansion and contraction of the headers and at the same time to provide a gas-tight seal and rigid construction. Preferably, this is accomplished by rounding the flange-engaging edges of the vertical and horizontal rails, the radius of curvature being substantially that between flange 10 and the face of header 9. When the clamps are bolted into place, the tapered flange-engaging surfaces of the clamps wedge the flanges and rails together to form a gas-tight fit, and due to the slope of the sides, this portion of the header is spaced from both the legs of the clamp and the rail, so that it can move in expanding and contracting. Although this construction will ordinarily be sufficiently gas tight, resilient packing material may be used if desired.

The spaces between the ends of the clamping members are filled in by plates 17 of appropriate shape, bolted to the rails. These plates also make gas-tight fit and prevent intermixing of gas and air.

It is desirable to provide for differential

expansion of the frame and radiator units, or tubes, and this is accomplished most simply by bolting the angles 11 at one end of the framework to channels 1 by means of bolts 20, the angles at the other end being free to slide against the face of the channels, as seen best in Figs. 2 and 7.

When used for preheating air from waste gases, it is usually desirable to pass the air through the tubes and gases over them. To that end, air ducts, not shown, are connected to the openings defined by channels 1 and plates 2; and gas ducts are similarly connected to the openings on opposite sides formed between channels 3 and 4. The two remaining sides, defined by channels 1 and 3, are most suitably closed by flanged plates bolted to the channels. These sides may be lagged if desired. Any suitable form of soot blower may also be installed in these side plates.

It will be seen that through the use of radiator units of standardized sizes, apparatus provided by the invention can be readily constructed to any desired height, width, and tube length. An appropriate number of units may be built up in a single apparatus, or two or more standard assemblies may be superimposed and bolted together, the apparatus described being especially adapted for such construction. Likewise, the use of units of different width, and the construction in a single or in multiple stacks gives flexibility in assembly to desired widths.

In using the apparatus as described above, with air passed through the tubes, all parts to be removed are accessible from the outside of the apparatus and from within the air ducts. This makes for very easy replacement of units and eliminates corrosion of the bolts, clamps, and similar parts.

In prior apparatus of this type, the tubes were expanded into the side walls during construction, this being generally done in its installation. Likewise the replacement of defective tubes was slow and tedious. In the new apparatus, the side plates are removed, and upon removal of the clamps retaining the unit containing the faulty tube, the unit may be easily withdrawn, and a new unit inserted. This materially reduces the amount of disassembly and makes repairs possible with a minimum loss of time and at low cost. It also eliminates the prior difficulties in tube assembly and the necessity of individually installing and removing tubes.

The use of oval tubes, in the preferred embodiment, possesses numerous operating advantages, as pointed out hereinabove. Likewise, the preferred form of units have no mechanical joints to become defective or offer trouble in other ways.

Expansion of the headers is adequately provided for, and the floating header construction eliminates the danger of undue strains being placed upon the tubes or headers upon their expansion or contraction.

Although especially adapted for use in preheating air for power boilers or gas or oil furnaces, by the heat contained in gases of combustion from the boiler, the apparatus is applicable for air conditioning, and generally to transfer of heat from any fluid medium to another.

I claim:

1. Heat exchanging apparatus comprising a framework, rails supported horizontally in two opposite ends in the framework, radiator units comprising parallel tubes and headers connected to the ends of the tubes disposed in the frame work with the headers slidably supported between the adjacent rails to be individually laterally removable from the framework, vertical bars positioned between the rails at the ends of the headers, and clamping members engaging said headers removably connected to said rail members and bars, the rails at one end of the apparatus being adapted to move in the framework to permit expansion of the radiators.

2. Heat exchanging apparatus comprising a framework built from structural section members, angle irons vertically positioned in each side of two opposite ends of the framework, a plurality of horizontal rail members connected at their ends to said angle irons, radiator units comprising parallel tubes of generally elliptical cross section and headers connected to the ends of the tubes, the units being positioned one above the other in the framework with the headers slidably supported between the adjacent rails to be individually laterally removable from the framework, clamping members engaging the horizontal edges of the headers removably connected to the rail members, bars vertically disposed between the rails at the sides of the headers, and clamping members engaging the sides of the headers removably connected to said bars, the angles at one end of the framework being connected to the framework, and those at the other end being free to move in the framework to permit differential longitudinal expansion and contraction between the radiators and framework.

3. Heat exchanging apparatus comprising a framework composed of structural section members, angle iron vertically positioned in each side of two opposed openings in the framework, horizontally positioned rail members connected at their ends to said angles and spaced therefrom by spacer blocks, interchangeable radiator units each comprising parallel tubes of generally elliptical cross section and flanged headers connected to the ends of the tubes disposed one above another in the framework, the headers being slidably supported between the adjacent rails and the flanges of the

headers bearing against the exterior surfaces of the rails, clamping members engaging adjacent horizontal edges of the headers removably connected to the rails, bars disposed vertically between the rails at the sides of the headers, and clamps engaging the sides of the headers removably connected to the bars, the angles at one end being connected to the framework and those at the other end being free to move, said units being individually laterally removable from the framework upon removal of the vertical and horizontal clamping members which hold it in position.

4. Heat exchanging apparatus according to claim 3, the corners of said rails and bars in contact with the flanges being rounded for engagement with the flange, and said clamping members having tapered flange-engaging arms adapted to wedge the flanges of adjacent headers against the rounded edge of the rails and bars, the sides of the headers being free to move between the rail and flange arm upon expansion or contraction of the header.

5. Heat exchanging apparatus comprising a structural section framework, angle irons vertically positioned in each side of two opposed ends of the framework, horizontal guide rails connected at their ends to said angle irons, interchangeable radiator units each comprising parallel tubes of generally elliptical cross section and flanged headers connected to the ends of the tubes disposed one above the other in said framework with the headers being slidably supported between the adjacent rails and the flanges being in contact with the external side of the rails, bars disposed vertically between the rails at the sides of the headers, the edges of the rails and bars in contact with the headers being rounded for engagement with the flange, and clamping members engaging adjacent edges of adjacent flanges removably connected to the rails and bars said clamping members comprising channels having arms the flange-engaging surfaces of which are tapered to permit movement of the sides of the headers between the rails and said arms, the outside vertical clamping members being also clamped to the angle irons, the angles at one end being free to move with respect to the framework and those at the other end being connected to the framework, and all of the connections being accessible from the outer side of the headers, whereby the units are individually laterally removable from the framework.

6. Heat exchanging apparatus comprising a structural section framework, angles vertically positioned in each side of two opposed ends of the framework, horizontal guide rails connected at their ends to said angles, a plurality of radiator units each comprising parallel tubes of generally elliptical cross section and flanged headers connected to the ends of the tubes, said units being inserted from opposite sides of the framework with the flanged headers slidably supported between the adjacent rails to form two banks of superimposed units, bars vertically disposed between the rails at the sides of the headers, the edges of the rails and bars in contact with the headers being rounded for engagement with the flange, and clamping members engaging adjacent edges of adjacent flanges removably connected to the rails and bars said clamping members comprising channels having arms the flange-engaging surfaces of which are tapered to permit the sides of the headers to move between said arms and rails upon expansion or contraction of the headers, the outside vertical clamping members being also clamped to the angle irons, the angles at one end being free to move with respect to the framework and those at the other end being connected to the framework, and all of the connections being accessible from the outer side of the headers, whereby the units are individually laterally removable from the framework.

In testimony whereof, I sign my name.

ARCHIBALD H. DAVIS, JR.