July 25, 1939. B. S. FOSS 2,167,333

HEAT EXCHANGER

Filed July 20, 1937 2 Sheets-Sheet 1

Fig. 1

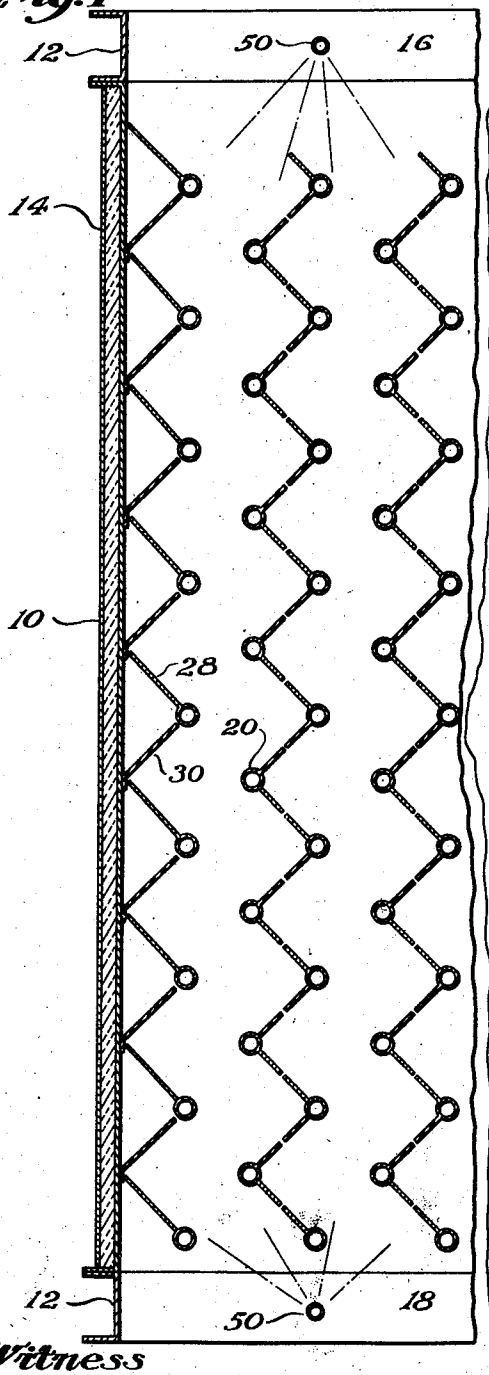
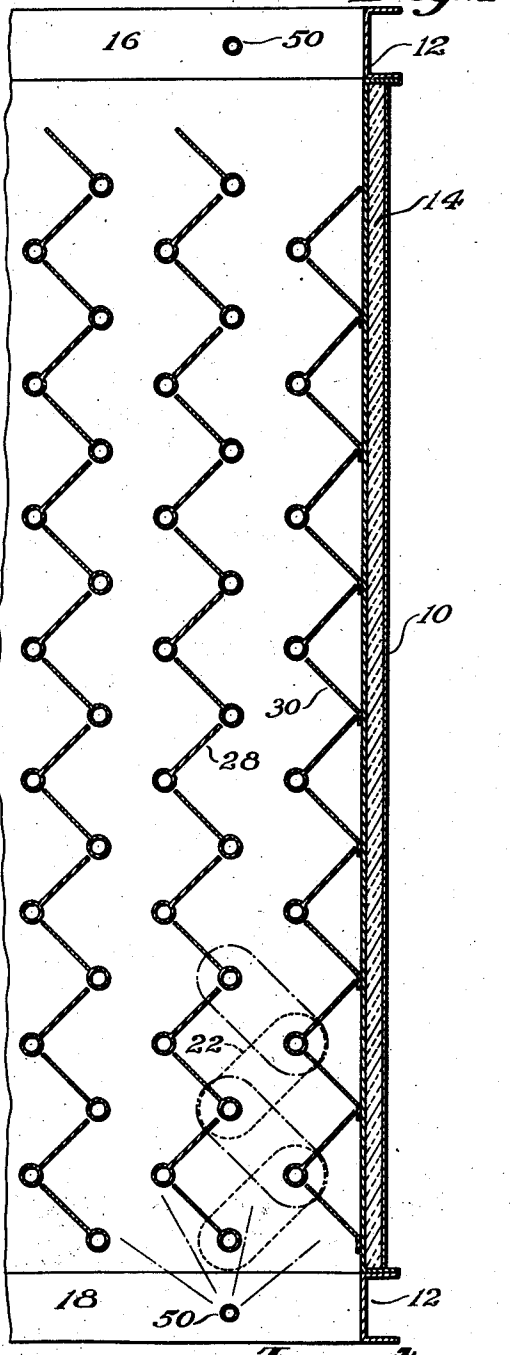


Fig. 2



Witness

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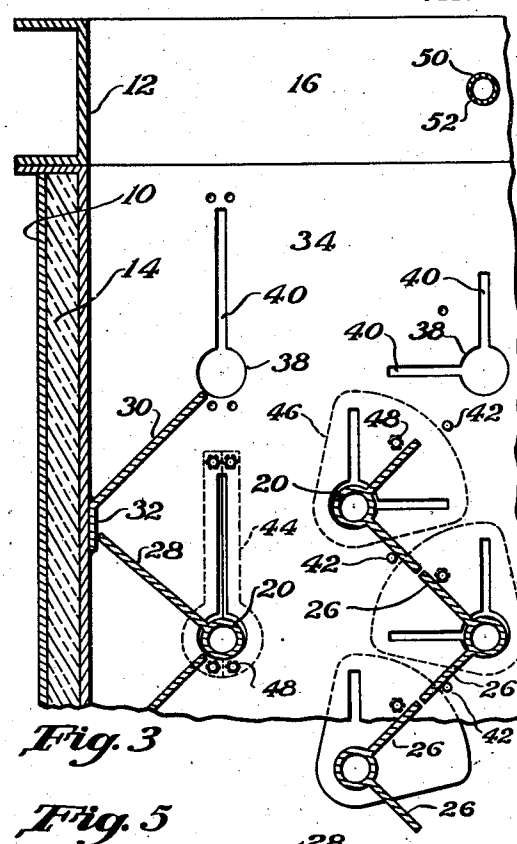


Fig. 3

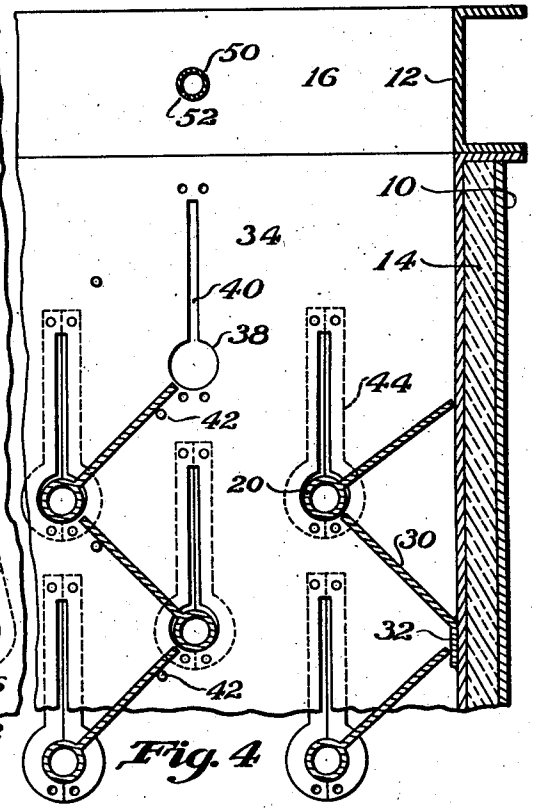
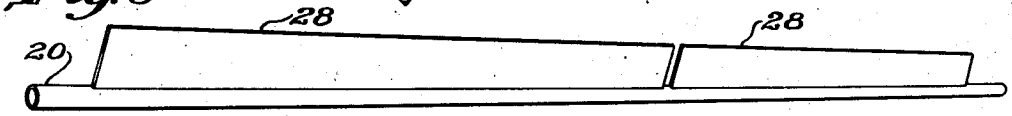


Fig. 4

Fig. 5



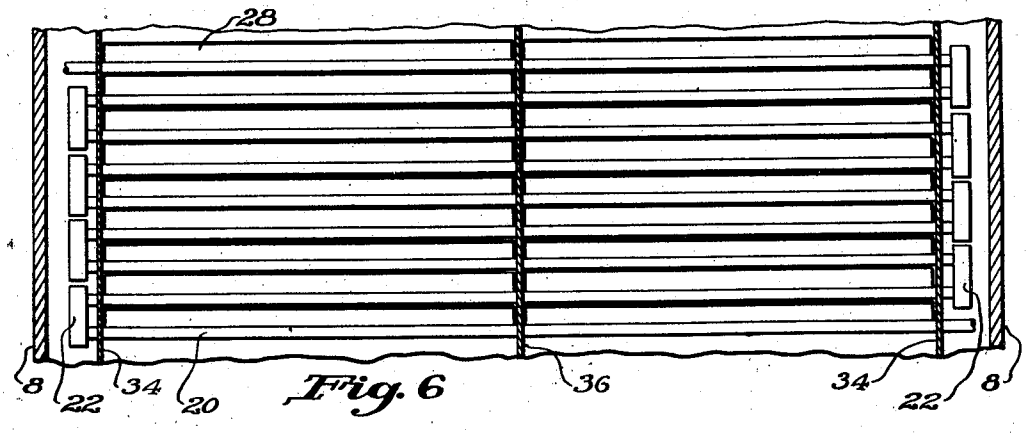


Fig. 6

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UNITED STATES PATENT OFFICE

2,167,333

HEAT EXCHANGER

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Application July 20, 1937, Serial No. 154,604

11 Claims. (Cl. 257—230)

The present invention relates to heat exchange apparatus, and more particularly to apparatus of the type which includes economizers and the like, wherein heat is extracted from gases and transferred to a fluid medium such as water.

In heat exchangers of this type the hot gases, such as flue gases, are caused to flow through a casing in which are arranged transversely of the direction of gas flow a series of fluid-conducting tubes, such apparatus being commonly employed as a pre-heater for boiler feed-water.

In apparatus of the above type, the efficiency of heat transfer from the gaseous to the fluid medium is dependent both on the amount of surface which the fluid-conducting members expose to the gases and on the velocity of the said gases over such surface. Closely related to the factor of velocity of gas flow is turbulence of flow, which results in all portions of the gas stream being brought into the intimate rubbing contact with the fluid-conducting members which is essential to high heat transfer.

Another feature of importance in securing high efficiency in this type of apparatus is the subjecting of all portions of the heating surface to substantially the same conditions of gas flow so that each portion will operate with the same efficiency as all the others.

One of the objects of the invention is to provide an economizer having fluid-conducting members of novel and improved construction, adapted to be arranged cooperatively to provide a large effective exposed surface, and to produce turbulence of flow and close rubbing contact of the gases without causing a high draft loss with accompanying expenditure of energy for driving the fan or other gas moving apparatus.

A further object of the invention is to provide an economizer or the like having improved tube supporting means particularly adapted for use with the fluid-conducting members embodying the invention to facilitate the assembling and the repair of the apparatus if such be found necessary.

Still another object of the invention is to provide an improved side wall construction adapted to be used advantageously in economizers embodying the several features of the invention.

To the accomplishment of the above stated objects, the present invention consists, generally speaking, in the provision in a suitable casing of a series of parallel, staggered, tubular fluid carrying members having one or more longitudinal flanges or fins formed thereon to provide extended or supplementary heating surfaces, the flanges of adjacent members being so disposed angularly with relation to one another that they close the spaces between certain of the adjacent members to form a series of practically separate, sinuous gas passages of substantially constant cross-sectional area throughout their length or extent through the economizer.

The tubular members are supported adjacent their ends in tube sheets and preferably one or both of these sheets are formed with apertures corresponding to the cross-sectional outline of the tubular members and their flanges, so that such members may be readily inserted in the assembled casing. To avoid undue weakening of the tube sheets by these apertures, the latter may be angularly disposed so as to leave a maximum amount of metal between them, the members being rotatively adjusted after insertion to bring the flanges into final operative position.

If desired, particularly with the longer tubes, one or more intermediate supporting sheets may be employed which will also be provided with apertures similar to and aligned with those in the tube sheets and through which the flanged tubular members may be passed when the members are being assembled in the casing, the flanges being interrupted at the points which will be opposite the supporting sheets when the members are completely inserted, thus permitting rotation of the members to proper angular position.

The side walls of the casing are provided with supplementary inclined flanges similar to the flanges on the tubes and properly inclined with respect thereto to form with the tube flanges a sinuous side wall.

In the accompanying drawings, Fig. 1 is a vertical, sectional elevation of a portion of an economizer embodying the invention, and Fig. 2 is a similar view of a portion of an economizer embodying an alternative form of the invention; Fig. 3 is an enlarged sectional detail of portions of the tube sheet of the economizer shown in Fig. 1, certain of the tubes being omitted; Fig. 4 is a similar view of the corresponding portion of the economizer illustrated in Fig. 2; Fig. 5 is a view in perspective of one form of fluid-conducting, tubular member; and Fig. 6 is a sectional view in side elevation of an economizer embodying the invention.

The casing of the economizer embodying the invention comprises end walls 8 and side walls 10, the walls being supported at top and bottom by a framework 12. The side walls 10 are double, with thermal insulating material 14 between the plates to reduce the heat loss from the casing.

The hot gases from the furnace or boiler, under the action of the usual forced or induced draft fan, are admitted to the space 16 above the fluid-conducting members, and, after passing downwardly between and giving up heat to these members, are conducted from the space 18 at the bottom of the casing to an exhaust stack or chimney.

The tubes 20 through which the boiler feed water or other fluid is conducted are arranged parallel to one another and transversely across the casing in a series of rows, the tubes of one row being disposed in staggered relation vertically with respect to the tubes of adjacent rows. The tubes are connected at their ends by the usual headers 22 to form a fluid conducting system. A satisfactory arrangement is to connect in a single series the two adjacent sets of vertically disposed tubes, so that the water flow is alternately through a tube of one set and then of the other, with oblique headers or return bends at the ends.

The tubes 20, which may be of cast iron or steel, depending on the pressure of fluid under which the apparatus operates, are provided with longitudinally extending fins or flanges which are integrally connected to said tubes by welding, or by being formed integrally therewith by casting. In the embodiment of the invention illustrated in Figs. 1 and 3, each tube in the interior portion of the economizer is formed with a pair of fins 26 mutually disposed at an angle, indicated in the drawings as approximately ninety degrees, while the tubes in the vertical row adjacent the wall are provided each with a single fin 26 arranged in a single plane and approximately twice the radial depth of the fins 26.

The tubes having the angularly disposed fins 26 are arranged as shown in Figs. 1 and 3 so that the fins of diagonally adjacent tubes are in alignment and substantially close the space between the said tubes. The tubes and fins thus arranged cooperate to provide a series of zigzag or sinuous passages extending through the economizer in the direction of gas flow. Due to the fins or flanges, a large amount of surface is exposed to the gases, and the heat absorbed by the fins is readily transferred by conduction through the members to the water or other liquid in the tubes. Furthermore, the frequent change in direction of gas flow caused by the zigzag shape of passage results in a turbulence and consequent intimate contact with the fins and tubes. The cross-sectional area of the gas passages is substantially constant, however, in the direction of gas flow, with the result that the weight velocity of the gases may be maintained at a substantially constant value without loss or waste from the slowing down and speeding up of the gas stream.

In furtherance of the effective transfer of heat from the gases to the liquid in the tubes afforded by the directed sinuous gas flow in the middle portion of the economizer, the side walls 10 parallel to the tubes are provided with similar fins or flanges 30 arranged to cooperate with the tubes and wide fins 26 of the vertical row adjacent the said walls. The fins 30 are provided along one edge with a portion 32 disposed at an angle to the main body of the fin and serving as a flange by which the fins are mounted on the side walls, the flange being secured by welding as shown in the drawings, or by other suitable means.

By the use of the fins 30 on the side walls of the economizer casing, the gas passages adjacent the walls are given substantially the same zigzag shape and cross-sectional area as the passages in the central portion of the apparatus with the result that the gas flow through all passages of the economizer is uniform both as to velocity and volume, thereby rendering all portions of the economizer equally efficient. In addition, the hot gases are deflected away from the walls, thereby reducing the heating of the walls and the resultant loss of energy therethrough.

The tubes are supported in the casing by means of the tube sheets 34 comprising steel plates or castings positioned transversely of the tubes adjacent the ends thereof and beyond the fins. Where the tubes are of substantial length, a similar supporting plate 36 may be used intermediate the ends of the tubes, the fins being interrupted, as illustrated in Figs. 5 and 6, to provide clearance for each member.

One or both of the tube sheets 34 and the supporting plate 36 are provided with apertures comprising circular tube receiving portions 38 and fin receiving slots 40, the portions 38 of the aperture being located to support the tubes so that the fins may cooperate as hereinafter described. The fin receiving slots 40 are provided to facilitate the assembly of the apparatus, and to make possible the withdrawal and replacement of individual tubes and attached fins without removing the supporting plates.

In order that the slots 40, through which the fins of the tubes are passed may not unduly weaken the tube sheets 34 and plates 36, as would be the case if the slots were arranged in zigzag fashion in alignment with the fins when the tubes are in operative position, the slots are oriented at an angle to said operative position of the fins. The tubes are thus passed through the tube sheets 34 and intermediate supporting plate 36 with the fins sliding through the slots 40. After a tube has reached its proper position longitudinally, with the fins free of the slots in the tube sheets and plate, the tube may be rotated to bring the fins into inclined position to cooperate with the fins of adjacent tubes.

The rotation of the tubes beyond proper position is limited by means of stop pins 42 mounted on the tube sheets 34 and adapted to engage the under side of the fins to maintain the latter in correct alignment with the fins of adjacent tubes.

In order to prevent the passage of the flue gases outwardly or of the fresh air inwardly around the tubes 20 and through the slots 40, the tube sheets 34 are provided with closures for covering such openings, the closures having circular apertures which fit snugly around the ends of the tubes. Two forms of closure are shown in the drawings, a two-piece or divided plate 44 being used for the tubes having fins arranged in a single plane, while a one-piece plate 46 is shown for the tubes having angularly disposed flanges. The closures or cover plates are secured to the tube supporting plates by means of bolts 48, the one-piece plate being placed in position before the headers 22 are connected, while the two-piece type of plate may be attached or removed with the headers in place.

The alternative embodiment of the invention illustrated in Figs. 2 and 4 differs from the construction first described only in that the fluid-conducting members throughout the economizer are of the type illustrated in Fig. 5, each having a single, radially deeper fin or flange. The gas passages are similarly arranged, and the mode of operation identical. As shown in Fig. 4, the clos-

ing means for the slotted portion of the aperture in the end plates is of the two-piece type 44 above described.

Soot blowers are provided at the top and bottom of the casing in the form of pipes 50 extending the length of the casing and provided with openings 52 through which steam is forced at high velocity into the economizer for loosening and removing accumulations of soot from the tubes and fins.

By substantially closing the space between diagonally adjacent tubes, there are formed a series of sinuous passages through the economizer which cause repeated and frequent changes in the direction of flow of the gases with the result that these are brought into the most intimate rubbing contact with the tubes, and because these expose practically all prime surface to the gases, the maximum rate of heat transfer is secured. Furthermore, since these passages are separate and distinct, stratification in the gas flow with loss of efficiency is avoided, and by spacing the tubes of each transverse row equal distances apart and staggering the tubes of adjacent rows with the oblique fins closing the space between diagonally adjacent tubes, the gas passages are formed all of equal cross-sectional area, thus securing an equal flow of gas through all portions of the economizer, with resulting high efficiency. Inasmuch as these gas passages have a substantially constant cross-sectional area throughout their length, there are no alternately occurring expansions and contractions in the gas stream with the draft losses incident thereto, but instead a substantially constant weight velocity or mean velocity or flow of the gases is maintained, with a minimum expenditure of energy required to move the gases through the economizer.

While in the drawings and specification there has been shown and described an economizer, so-called, for transferrng heat from the waste gases to the boiler feed water, it is to be understood that the present invention is not limited thereto, but covers broadly other forms and types of heat exchangers wherein the heat is abstracted from one fluid medium and transferred to another fluid medium, irrespective of whether said mediums are liquid or gaseous, the term "fluid medium" in the specification and claims meaning and covering both gases and liquids.

Nor is the present invention limited to the particular construction or form and arrangement of the parts herein shown and described, but may be embodied in other constructions and other forms and arrangements without departing from the spirit of the invention as herein described in the appended claims. For example, the tube elements need not necessarily be provided with straight or plane fins, nor must the sinuous passages be defined by straight wall portions between diagonally adjacent tubes.

Having thus described the invention, what is claimed is:

1. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, and longitudinal fins affixed to the tubes, said fins being arranged in zigzag fashion to form sinuous passages in the direction of gas flow.

2. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, and longitudinal fins affixed to the tubes, said tubes being arranged with the fins extending obliquely between alternate diagonally adjacent tubes to form sinuous passages in the direction of gas flow.

3. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, longitudinal fins on the tubes, said tubes and fins being arranged to form sinuous passages in the direction of gas flow, means for supporting the tubes adjacent the ends thereof comprising members arranged transversely of the tubes and extending across the casing, said members being provided with apertures through which the tubes and attached fins may be passed, the fin-receiving portion of each aperture being oriented at an angle to the position of the fins when the tubes are in operative position, and means for closing said portion of the apertures.

4. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, longitudinal fins on the tubes, said tubes and fins being arranged to form sinuous passages in the direction of gas flow, and means for supporting the tubes adjacent the ends thereof and at an intermediate point, comprising members arranged transversely of the tubes and extending across the casing, said members being provided with apertures having fin and tube receiving portions to permit the insertion and withdrawal of the tubes and attached fins, the fin receiving portion of each aperture being oriented at an angle to the position of the fins when the tubes are in operative position.

5. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, longitudinal fins affixed to the tubes, said tubes being arranged with the fins substantially closing the spaces between alternate diagonally adjacent tubes to form sinuous passages in the direction of gas flow, and means adjacent the side walls of the casing and cooperating with the tubes and fins in the row adjacent said walls to form along said walls sinuous passages in the direction of gas flow substantially similar to the passages formed by the tubes and fins in the middle portion of the casing.

6. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, longitudinal fins affixed to the tubes, said tubes being arranged with the fins substantially closing the spaces between alternate diagonally adjacent tubes to form sinuous passages in the direction of gas flow, and a plurality of fins extending along and secured adjacent one edge to the walls of the casing parallel to the tubes, said fins being disposed at an angle to the walls and arranged to cooperate with the tubes and flanges of the row adjacent each of said walls to form sinuous passages in the direction of gas flow along the walls similar to the passages formed by the tubes and fins in the central portion of the casing.

7. A heat exchanger for extracting heat from gases comprising a casing forming a passage

through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, longitudinal fins on the tubes, said tubes and fins being arranged to form sinuous passages in the direction of gas flow, means for supporting the tubes adjacent the ends and beyond the fins comprising members arranged transversely of the tubes and extending across the casing, said members being provided with apertures through which the tubes and fins may be passed, and abutment means on said members adapted to engage the fins to determine and maintain the position of the tubes after insertion in the casing.

8. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing with the tubes of one row staggered with respect to the tubes in adjacent rows, and longitudinal fins on the tubes, the fins on diagonally adjacent tubes being obliquely arranged alternately to one side and to the other to close the spaces between the tubes and form a series of sinuous gas passages.

9. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, the tubes in each row being equally spaced from one another and staggered with relation to the tubes in adjacent rows, and means for closing the spaces between diagonally adjacent tubes to form a series of sinuous gas passages of equal cross-sectional area.

10. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged transversely of the passage in the casing, the tubes of each transverse row being equally spaced from one another and offset from the adjacent tubes of adjacent rows, and means for closing the spaces between diagonally adjacent tubes to form a series of sinuous passages, each having a substantially constant cross-sectional area throughout its length.

11. A heat exchanger for extracting heat from gases comprising a casing forming a passage through which the gases flow, a plurality of fluid-conducting tubes arranged in rows transversely of the passage in the casing, longitudinal fins on the tubes, said fins terminating short of the ends of the tubes and extending obliquely between the tubes to form sinuous passages in the direction of gas flow, and means for supporting said tubes within the casing comprising members extending across the casing transversely of the tubes adjacent the ends thereof and free of the fins thereon, said members being provided with apertures through which the tubes and attached fins may be passed.

BENJAMIN S. FOSS.